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STORAGE

I. HISTORY OF THE OPERATIONS AGAINST BUD-ROT OF PALMS IN SOUTH INDIA

II. INOCULATION EXPERIMENTS WITH *PHYTOPHTHORA PALMIVORA* BUTL. ON *BORASSUS FLABELLIFER* LINN. AND *COCOS NUCIFERA* LINN

BY

W. McRAE, M.A., B.Sc

Ag. Imperial Mycologist

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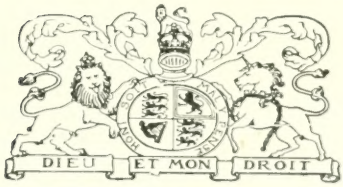

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PREFACE

THE following account of the operations against bud-rot of palms in South India is written because the application of the Pest Act marks the end of a phase of the operations and the continuance of the work from July 1920 passed to the hands of M. R. Ry. S. Sundararaman Avargal, my successor as Government Mycologist in the Madras Department of Agriculture. I have pleasure in acknowledging great assistance from him in the work during the eleven years he was my chief assistant.

W. McRAE.

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I. HISTORY OF THE OPERATIONS AGAINST BUD ROT OF PALMS IN SOUTH INDIA.

BY

W. McRAE, M.A., B.SC.,

Ag. Imperial Mycologist.

[Received for publication on 23rd November, 1922.

Account of the operations in Godavari and Kistna Districts.

In 1904 the outbreak of a serious disease of the palmyra palm, *Borassus flabellifer* Linn., in the Godavari delta on the east coast of the Madras Presidency was reported and Dr. Butler, the Imperial Mycologist, paid a visit to the delta in August 1905. The result of his investigation determining the cause to be *Phytophthora palmivora* Butl., the measures he recommended and the early history of the operations undertaken against the disease are given in his paper entitled the "Bud-rot of palms in India."[1] For the details of the operations to the end of 1909 his paper should be consulted, but I shall give a résumé of what was done up to that time in order to make clear the further account of the operations which this paper presents. Briefly the recommendations were (1) the formation of a special staff of agricultural inspectors or some similar officials under whom would work groups of expert palm-climbers, (2) that some of the latter should cut off the green tops below the swelling of the leaf-sheaths from all diseased trees both those in the early stages and those already dead, (3) that after cutting off the heads the whole of the tops should be collected into a heap in each village and burned, and (4) that other palm-climbers should brush Bordeaux mixture on the leaf-sheaths of healthy trees in places where the latter were surrounded by large numbers of dead and dying trees, in order to diminish the chances of infection.

In December 1906 trial measures were instituted by the Agricultural Department of Madras in three *firkas* or sub-divisions of Cocanada,

[1] Butler, E. J. *Mem. Dep. Agri. India, Bot. Ser.*, Vol. III, pp. 221-280, 1910. Fungi and Disease in Plants, p. 95, 1918.

Ramachandrapur and Amalapur Taluqs, and by March 1907 about 40,000 diseased trees had been dealt with. This was in reality but an experiment to gain experience and to see whether the measures were practicable, for there was some doubt and hesitation at first in undertaking remedial measures on the large scale that was obviously required. The main difficulties that were encountered in carrying out the work are given in pages 266 to 270 of Dr. Butler's memoir. Some of them have remained throughout the operations, while others have been to a great extent overcome.

In June 1907 operations on a large scale with eight revenue inspectors were begun in Amalapur Taluq, but still only a fraction of the infected area was tackled. The general control was entrusted to an Assistant Collector while three mycological assistants and an agricultural demonstrator were appointed as supervisors. "By December 1907 the whole of the infected area of Amalapur Taluq had been worked over and all the old cases cut out. The first return visit had been paid in most villages and the second was in progress. This set free a portion of the staff and the work was accordingly extended to Ramachandrapur Taluq by the beginning of 1908. A considerable recrudescence in Amalapur Taluq in January and February 1908 detained about half the staff south of the Gautami until the hot weather. By the 1st April 1908 the returns showed that 177,000 palms had been cut in Amalapur Taluq since the beginning of the operations and probably over a quarter of a million in the whole area."[1] In October 1908 the Assistant Collector was transferred and as his successor, a Special Deputy Collector, did not join till July, the work suffered through want of supervision. Before this two of the supervisors had been withdrawn and soon afterwards the other two left. Up to October 1908 actual cutting was done by hired tappers (palm-climbers) working under the direction of revenue inspectors who moved with their parties from village to village. Each revenue inspector had to visit every village in his range, engage the necessary tappers for cutting and coolies for burning and personally supervise the operations in the field. The number of villages in each range being large, the interval between one visit and the next was too great. So long as it was believed that the disease progressed rapidly and continuously from the time of infection to the death of the tree and that a new outbreak could not occur in cleared-up areas without infection from outside the arrangement seemed satisfactory, but the repeated recrudescences in Amalapur Taluq suggested that the interval between infection and death was much longer than was anticipated. Besides, up to this time, only

[1] Butler, E. J. *Mem. Dep. Agri. India, Bot. Ser.*, Vol. III, p. 270, 1910. Fungi and Disease in Plants, p. 95, 1918.

a portion of the infected area in the Godavari District had been worked over, while the Kistna District was untouched. This way of carrying out measures against the disease was thus obviously ineffective both with regard to the area covered and to the whole infected area.

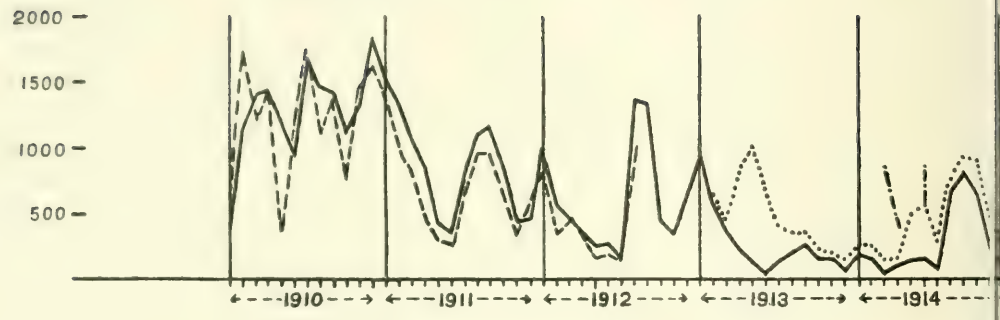
From October 1908 accordingly Mr. Green, the Special Deputy Collector, introduced a new system of carrying out the operations under which actual cutting and burning was to be carried out by the tappers and village servants under the direction of the village officers upon whom was thrown the responsibility for getting the work done. The members of the special staff were relieved of the actual cutting and burning of dead palms and became inspecting officers. This was the aim of the new system but only gradually did it take effect in practice and not till 1920, when the Pest Act was applied, was it fully realized. A great improvement also was the fact that for the first time the whole of the known infected area in the Godavari District was brought under the operations at the end of 1908 and that of the Kistna District in 1910.

While the village officer was moving about in the village on revenue duty he noted the position of dead trees and arranged to have them cut. When large numbers of dead palms were found in small areas it was easy, but it was difficult to get a tapper to cut isolated palms or groups of palms scattered throughout a village whose area might be ten square miles, because he had to spend a considerable amount of time and energy going about the village for a small return. At first the trunks of the cut trees were tar-marked and afterwards they were numbered with different coloured paints to distinguish those of different years. Though tedious, this was necessary in the beginning till the village officers and revenue inspectors became accustomed to the work. Because of the obliteration of the numbers by weathering and the consequent loss of the field record, registers were maintained from 1914 showing the survey number of every field in which disease was found, and month by month the numbers of dead palms cut were marked in the appropriate places. The revenue inspectors took the registers out with them and checked the number of headless stems in each field, noted any recently dead palms they saw and paid for the cost of cutting the trees which at different times varied from $\frac{1}{4}$ to $1\frac{1}{2}$ annas per tree. The village officers and the revenue inspectors reported the number cut and the number paid for respectively, the idea being that the one set of figures would be a check on the other. During 1909 and 1910, however, there was always a discrepancy between the monthly numbers reported and a very great difference between the sums of the two sets of figures for the year. In the graph for Kistna District is given as a dotted

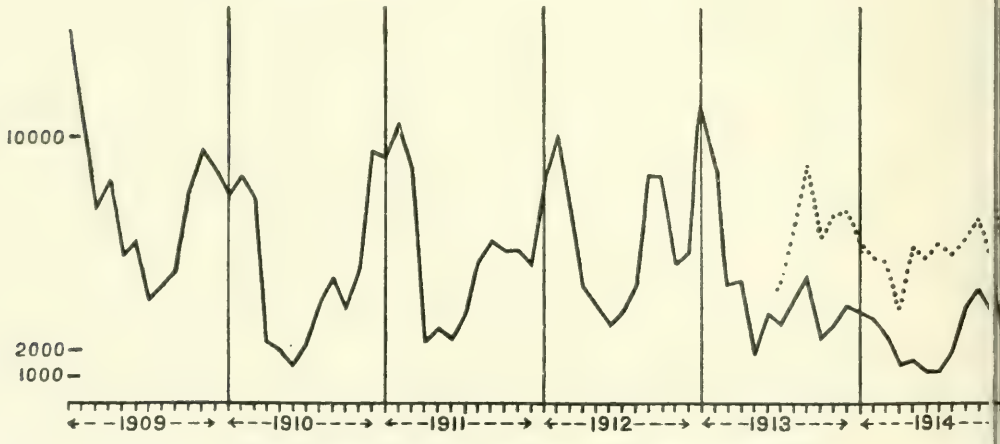
line the figures reported by the village officers for 1910, 1911 and 1912, and as a continuous line those reported by the revenue inspectors as paid for during those years. As was to be expected in the first year the two curves differ widely, but in 1910 and 1911 they approximate closely. After a thorough investigation the reports of the village officers were discontinued as being unreliable and in the circumstances impracticable to make accurate. The village officers had a great deal of other regular work to do especially in the double crop lands where the disease was worst, besides the operations were very unpopular with the cultivators. The village officers accordingly had much reason for, and many opportunities of, relegating the operations to a secondary place or even doing little or nothing especially where a revenue inspector was none too eager to walk about the fields in the hot sun inspecting what had been done. Too often the work was left till the arrival of the revenue inspectors in the village when a spurt was made to get the dead trees cut. However, too much must not be made of this. The difficulties of introducing an entirely new and little understood system of dealing with a disease were very real and entailed patient, continuous effort to overcome. Gradually as the years passed the work was better done and the tree owners were even induced to bear the cost of the tappers' wages, thus showing that they did ultimately have some belief in the operations, and from 1915 onwards the cost of the special staff was practically all that fell to be charged to Government funds. The years from 1909 in the Godavari District and 1910 in the Kistna District till 1912 were spent in getting the operations as efficient as possible. During this time there was a gradual slight increase in the number of dead palms dealt with, and facts were gradually accumulating that led to more intensive measures for dealing with the disease in the field, but these will be discussed later.

The record of the numbers of diseased palms dealt with during the fifteen years the operations have been in existence is given in Tables I—III and graphically in Plate I where graphs are given for Kistna and Godavari Districts. These two blocks were kept separate with a view to seeing more clearly what was going on in the infected area, for in several ways they had separate characteristics. For the sake of convenience in recording the figures the diseased palms were divided into three categories corresponding somewhat to the symptoms of the disease, *viz.*, (1) *dead palms* in which the central leaf or group of leaves was dead indicating that the growing point was dead, (2) "*outwardly infected*" *palms* in which one or more of the leaves had characteristic rows of spots indicating that the growing point was still alive and (3) "*inwardly infected*" *palms* in which the presence of the disease was

Kistna District.



Godavari District.

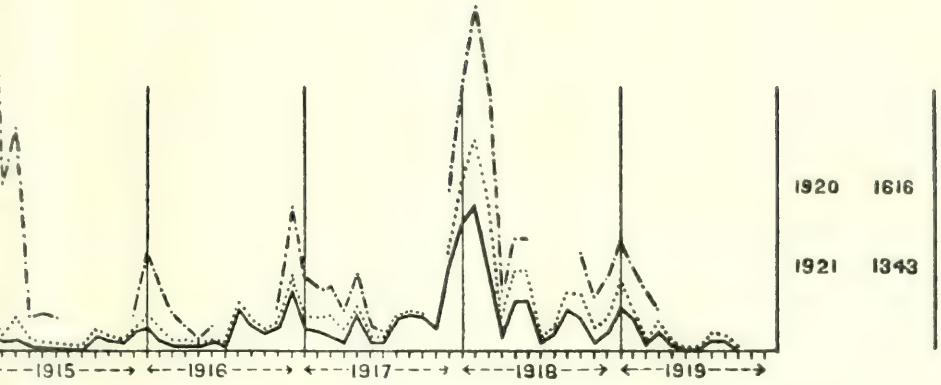


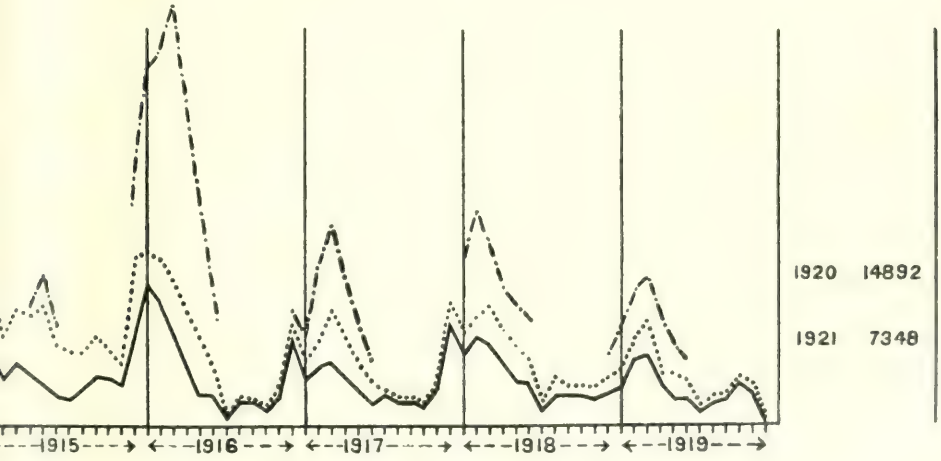
——— *Number of dead palms cut in a month.*

..... „ *dead + outwardly infected palms.*

.-.-.- „ *dead + „ „ „ inwar*

– – – – „ *dead palms reported by village offi*





infected palms .

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Table I.

Yearly figures of cuttings.

Year	Godavari District				Kistna District				Total			
	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total
1907 ..	..	..	215,229	215,229	..	..	..	..	..	..	215,229	215,229
1908 ..	..	..	183,100	183,100	..	..	..	..	..	..	183,100	183,100
1909 ..	..	..	91,849	91,849	..	..	..	..	..	..	91,849	91,849
1910 ..	..	..	58,765	58,765	..	..	15,561	15,561	..	..	74,326	74,326
1911 ..	..	..	67,921	67,921	..	..	10,466	10,466	..	..	78,387	78,387
1912 ..	..	..	72,345	72,345	..	..	7,107	7,107	..	..	79,452	79,452
1913 ..	..	19,088	55,204	74,292	..	3,122	3,265	6,387	..	22,210	58,469	80,679
1914 ..	570	38,765	32,842	72,177	4,792	2,347	3,515	10,654	5,362	41,112	36,357	82,831
1915 ..	5,733	23,379	21,847	50,959	6,629	673	721	8,023	12,362	24,052	22,568	58,982
1916 ..	11,337	11,791	25,133	78,261	1,830	711	1,696	4,237	43,167	12,502	26,829	82,498
1917 ..	12,286	8,370	19,873	40,529	1,662	882	2,497	5,041	13,948	9,252	22,370	45,570
1918 ..	12,837	11,529	20,987	45,353	4,080	2,616	4,488	11,184	16,917	14,145	25,475	56,537
1919 ..	7,517	7,717	15,860	31,094	665	703	975	2,343	8,182	8,420	16,835	33,437
1920 ..	..	..	14,892	14,892	..	..	1,616	1,616	..	..	16,508	16,508
1921 ..	..	..	7,349	7,349	..	..	1,343	1,343	..	..	8,692	8,692
Total ..	80,280	120,639	903,196	1,104,115	19,658	11,054	53,250	83,962	99,938	131,693	956,446	1,188,077

TABLE II.

Monthly figures of cuttings in Godavari District.

Month	1909	1910	1911	1912	1913			1914				1915			
	Dead	Dead	Dead	Dead	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total
Jan. ..	14,090	7,731	9,194	8,348	..	11,139	11,139	..	2,519	3,416	5,935	..	2,801	2,614	5,415
Feb. ..	10,532	8,688	10,590	10,172	..	8,965	8,965	..	2,219	3,182	5,401	..	1,630	1,664	3,294
March ..	7,284	7,745	8,948	7,301	..	4,365	4,365	..	2,864	2,503	5,367	..	2,123	2,291	4,414
April ..	8,534	2,280	2,140	4,306	..	4,892	4,892	..	2,321	1,375	3,696	221	2,218	1,930	4,369
May ..	5,636	2,014	2,853	3,623	..	1,838	1,838	..	4,378	1,555	5,933	1,125	3,096	1,398	5,619
June ..	6,153	1,401	2,389	2,882	..	3,325	3,325	570	4,313	1,111	5,994	713	1,966	1,061	3,740
July ..	3,826	2,186	3,439	3,353	1,453	2,972	4,425	..	4,819	1,226	6,045	..	1,832	964	2,796
Aug. ..	4,487	3,865	5,367	4,322	1,853	3,890	5,743	..	3,738	1,923	5,661	..	1,333	1,395	2,728
Sept. ..	4,940	4,800	6,254	8,619	4,232	4,755	8,987	..	2,604	3,598	6,202	..	1,391	1,946	3,337
Oct. ..	8,054	3,583	5,754	8,634	3,844	2,434	6,278	..	2,650	4,308	6,958	..	1,067	1,789	2,856
Nov. ..	9,561	4,860	5,793	5,096	4,121	2,967	7,088	..	2,228	3,197	5,425	245	785	1,486	2,516
Dec. ..	8,752	9,612	5,200	5,689	3,585	3,662	7,247	..	4,112	5,448	9,560	3,429	3,137	3,309	9 875
TOTAL ..	91,849	58,765	67,921	72,345	19,088	55,204	74,292	570	38,765	32,842	72,177	5,733	23,379	21,847	50,959

TABLE II *contd.*

Monthly figures of cuttings in Godavari District.

Month	1916				1917				1918				1919			
	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total
Jan. ..	6,739	1,190	5,408	13,337	1,132	647	1,663	3,442	2,679	921	2,610	6,210	1,265	794	1,475	3,534
Feb ..	7,749	1,646	4 707	14,102	2,928	939	2,283	6,150	3,097	1,710	3,445	8,252	1,580	1,002	2,454	5,036
March	10,446	2,181	3,331	15,958	3,331	1,471	2,950	7,752	2,353	1,445	3,126	6,924	1,663	1,352	2,634	5,649
April ..	7,558	2,039	2,334	11,931	2,195	1,568	1,894	5,657	1,427	1,341	2,453	5,221	1,342	1,218	1,705	4,265
May ..	5,117	2,196	1,175	8,488	1,186	1,160	1,405	3,751	1,482	1,478	1,716	4 676	1,077	1,030	1,011	3,118
June ..	3,108	1,226	1,060	5,394	839	858	775	2,472	1,077	1,260	1,552	3,889	590	757	1,055	2,402
July ..	33	67	233	333	99	266	1,062	1,427	5	460	511	976	..	238	538	776
Aug. ..	39	262	871	1,172	10	222	966	1,198	..	762	1,107	1,869	..	371	987	1,358
Sept. ..	..	195	830	1,025	..	184	879	1,063	..	508	1,091	1,599	..	316	1,060	1,376
Oct. ..	..	135	565	700	6	149	705	860	..	508	1,095	1,603	..	295	1,540	1,835
Nov. ..	45	257	1,251	1,553	62	171	1,313	1,546	..	505	1,029	1,534	..	327	1,293	1,620
Dec. ..	503	397	3,368	4,268	498	735	3,978	5,211	717	631	1,252	2,600	..	17	108	125
TOTAL	41,337	11,791	25,133	78,261	12,286	8,370	19,873	54 029	12,837	11,529	20,987	45,353	7,517	7,717	15,860	31,094

Table III.

Monthly figures of cuttings in Kistna District.

Month	1910	1911	1912	1913			1914				1915				1916			
	Dead	Dead	Dead	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total
Jan. ..	367	1,546	1,010	..	978	978	..	89	202	291	3,345	172	104	3,621	501	92	194	787
Feb. ..	1,169	1,356	581	66	590	656	..	68	173	241	1,116	57	68	1,241	365	110	75	550
March ..	1,419	1,075	417	102	348	450	713	67	69	849	1,456	160	87	1,703	162	66	25	253
April ..	1,490	882	352	633	213	846	250	57	105	412	158	72	36	266	59	55	35	149
May ..	1,264	411	264	949	131	1,080	21	341	152	514	217	49	18	284	45	17	18	80
June ..	937	346	296	646	25	671	281	417	153	851	210	31	17	258	58	71	67	196
July ..	1,726	817	159	302	112	414	..	219	72	291	..	9	14	23	..	9	24	33
Aug. ..	1,497	1,103	1,368	150	199	349	..	89	688	777	..	1	14	15	..	49	318	367
Sept. ..	1,476	1,190	1,325	103	262	365	..	103	810	913	..	50	110	160	..	48	184	232
Oct. ..	1,103	837	415	55	174	229	..	218	650	898	..	16	81	97	..	40	112	152
Nov. ..	1,279	428	317	62	141	203	328	284	192	804	..	21	45	66	117	29	278	324
Dec. ..	1,834	475	603	54	92	146	3,199	365	249	3,813	127	35	127	289	523	125	466	1,114
TOTAL ..	15,561	10,466	7,107	3,122	3,265	6,387	4,792	2,347	3,515	10,654	6,629	673	721	8,023	1,830	711	1,696	4,237

TABLE III—*contd.*

Monthly figures of cuttings in Kistna District.

Month	1917				1918				1919				1920	1921
	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total	Inwardly infected	Outwardly infected	Dead	Total		
Jan.	334	73	182	589	720	348	904	1,972	281	223	315	819	..	..
Feb.	238	83	168	489	1,007	517	1,100	2,624	208	176	250	634	..	..
March ..	226	133	134	493	805	450	653	1,908	66	19	32	117	..	..
April	126	86	80	292	191	159	91	441	91	106	118	315	..	..
May	175	151	280	606	465	482	782	1,729	18	34	34	86	..	..
June .. .	93	59	43	195	..	..	..	..	1	5	4	10	..	..
July	..	52	61	113	..	53	59	112	..	8	7	15	..	..
Aug.	..	25	226	251	..	75	115	190	..	70	92	162	..	..
Sept.	..	37	283	320	..	115	345	460	..	48	90	138	..	..
Oct.	..	33	250	283	326	170	265	761	..	14	33	47	..	..
Nov.	56	23	161	240	225	134	46	405	..	..	..	..	..	..
Dec.	114	127	629	1,170	341	113	128	582	..	..	..	..	..	..
TOTAL ..	1,662	882	2,497	5,041	4,080	2,616	4,488	11,184	665	703	975	2,343	1,616	1,343

detected by stripping the leaf-bases from palms that showed no outward symptoms of disease but that grew in the vicinity of dead or outwardly infected palms. These terms have no significance other than that given in the definitions. They were evolved in talking with the special staff about the work in the field and crept into use in administrative reports as being a convenient way to indicate the appearance of diseased palms as dealt with in the stages of the operations. The numbers of the trees dealt with were reported in this way in order that we might be the better informed as to the progress of the operations. The outwardly infected and inwardly infected trees had all the diseased tissue excised and thus were given a chance of recovery.

With regard to the value of the figures, those of the first category have a reasonable degree of accuracy as it is easy enough to distinguish a dead tree, while those of the other two are not quite so accurate being most probably a little too high especially in the second category. The village officers at first did not always distinguish between rows of spots caused by the fungus and rows of holes caused by the rhinoceros beetle. Again the death of the central leaf or even the two next to it does not absolutely mean that the central growing-point is dead, though as a matter of fact it generally does so from the point of view of the ordinary operations. If the crown is dissected immediately the leaves show the yellow discoloration, the growing-point in a great many cases is found not to be dead and the tree can be saved. But a few days later the tissue about the growing-point becomes involved in the rot and it is too late to save the tree. During the "detailed examination" of trees mentioned on page 36 and succeeding pages such cases would be dealt with in increasing numbers and they would naturally be included among the outwardly infected palms for the lack of another division into which to put them. The trees were diseased and were saved as the outwardly infected ones were. The only material error in the second category, I think, crept in during 1914 when outwardly infected palms were first being dealt with on a large scale in the Godavari District. On page 4 of a note on the "Rows of Spots on Palmyra Palms" published in the *Agricultural Journal of India*, VII, 1912, I gave three examples in which the percentage of outwardly infected palms was 17, 8 and 3·4 respectively, and mentioned that I thought the percentage of such trees over the whole area was slightly below the last figure. The numbers of the outwardly infected and dead palms in Godavari District from July 1913 when the former began to be cut till December 1914 are as follows :—

Month	Outwardly infected	Dead		
July 1913	1,453	2,972	or 1 : 2 or 33	per cent.
Aug. ,, ...	1,853	3,890	1 : 2	32 ,,
Sept. ,, ...	4,232	4,755	1 : 1	47 ,,
Oct. ,, ...	3,844	2,434	8 : 5	61 ,,
Nov. ,, ...	4,121	2,967	8 : 6	58 ,,
Dec. ,, ...	3,585	3,662	1 : 1	49 ,,
Jan. 1914	2,519	3,416	5 : 7	42 ,,
Feb. ,, ...	2,219	3,182	2 : 3	41 ,,
Mar. ,, ...	2,864	2,503	1 : 1	53 ,,
Apr. ,, ...	2,321	1,375	11 : 7	62 ,,
May ,, ...	4,378	1,555	3 : 1	73 ,
June ,, ...	4,313	1,111	4 : 1	71 ,,
July ,, ...	4,819	1,226	4 : 1	79 ,,
Aug. ,, ...	3,738	1,923	2 : 1	66 ,,
Sep. ,, ...	2,604	3,598	2 : 3	42 ,,
Oct. ,, ...	2,650	4 308	5 : 8	38 ,,
Nov. ,, ...	2,228	3,197	2 : 3	41 ,,
Dec. ,, ...	4,112	5,448	4 : 5	43 ,,

Even taking into account the reservation made in the early part of this paragraph the number of outwardly infected trees is too high in all these months. Anything like these numbers of outwardly infected palms would have been strikingly conspicuous, but the appearance in the delta was not so. I am willing to admit that my first estimate was far too low but not to the extent that these figures indicate. Again through an unfortunate misunderstanding the person then in charge of the operations thought the relative proportion of outwardly infected to dead palms should not be less than 2 : 1. and in April 1914 issued instructions accordingly to all revenue inspectors and threatened penalties if the reports showed otherwise. It was only after I had had several monthly reports and noticed the unexpectedly high proportion that I found this out, had the instructions cancelled and took pains to have the inspectors carefully instructed. The figures for the inwardly infected palms are fairly accurate. The only likely error would be the inclusion of trees that had brown blotches on the leaf-sheaths especially near the edges, but as these are not at all like the spots caused by the fungus this error would be insignificant after the first detailed examination of trees. I have no means of accurately estimating the errors which on the whole are small and not, I think, any greater than in field work of the class, so I shall use the figures in the discussion as they stand.

I shall now describe the working of the operations from year to year from 1910 onwards mentioning the salient features of the work as they crop up. In 1910 there were 566 villages within the infected area in Godavari District and cuttings were made in 208, while in Kistna District out of 710 villages cuttings were made in 35 in January and 103 in December. The

total number of dead trees cut this year in the whole infected area was considerably less than the number cut in the previous year in Godavari District alone, and this gave considerable encouragement with regard to the continuance of the operations. In 1911 on the transference of the Special Deputy Collector he was replaced by two Tahsildars, one for each district, as the two districts were found to be too large for a single officer to supervise properly, and the staff in Godavari District was increased. By 1912 the spread of the disease was definitely checked in both districts. In Kistna District the number of dead palms cut was high in parts of the taluqs of Kovur, Tanuku and Narsapur, but beyond that area there were so few cuttings that the rest of these taluqs and the whole of Bunder and Bhimavaram Taluqs were handed over to the ordinary revenue staff which became responsible for cutting sporadic cases that might occur and for reporting any serious outbreak to the Special Tahsildar. In Godavari District two new infected places at Pittapur and Jagapetinagaram were found in the uplands eight and twelve miles from Samalkota which is at the edge of the delta. In one case the infected area was about forty and in the other about ten acres, the former being situated on one side and the other on both sides of a main road and each being beside a small tank. Both were miles away from the nearest known infected area and from their position it looks as if the disease has been transported there by human agency. In the latter of them 203 dead trees were cut. 584 trees surrounding them were examined by cutting off 17 or 18 of the lower leaf-sheaths and 99 of them were found to be diseased. All had the diseased tissue completely excised and all recovered. From this place the disease was later completely eradicated (no deaths having occurred during the last five years), but occasional deaths still occur in the other. The Collector placed one revenue inspector on duty solely in the uplands so that a better watch could be kept over a belt of five miles on the edge of the infected area in Godavari District. In the years 1911 and 1912 the number of dead trees was slightly above that of 1910 and in the latter year was recorded the highest number of deaths since 1909, but after this date the number gradually and continuously declined. During this period was conducted a set of inoculation experiments which are described separately at the end of this paper.

About this time a proposal was made to abandon the attempt to control the disease within the infected area and to substitute a plan of patrolling a belt round the boundaries of that area. Fortunately, however, the proposal was dropped for obvious reasons; the chief of which being that the number of diseased trees in the infected area was too small a percentage of the total to justify the sacrifice of all, that the patrol of the belt would have had to

continue till most of the trees in the infected area had taken the disease and died, and thus, because of the slow rate of development and spread of the fungus, there would be no determinable limit to the operations, and that there was no certainty that a carefully patrolled belt of reasonable dimensions would stop the spread of the disease beyond it as it was still possible for the disease to be transported long distances by human agency. Effort was accordingly directed to improving the system already in practice.

In 1913 the number of dead trees cut over the whole area fell considerably. Up to this time, however, only dead palms were being destroyed, but a fairly large number of diseased palms showed the presence of disease in the appearance of rows of spots on the laminæ of the leaves.[1] It was found that, when such a leaf protruded from the bud and began to open, the mycelium developed on the surfaces of the spots and produced sporangia in favourable circumstances such as when there was dew in the cold season or a highly moisture-charged atmosphere during the monsoon. In the presence of water, the sporangia discharged zoospores freely and their position on the topmost leaf of the palm was an excellent one for dissemination by dripping on the supporting palm or to lower ones or by rain splashing the zoospore-charged drops of water on the leaf to surrounding palms. Older leaves, however, though they retain traces of mycelium on the old spots, did not appear to have it in an active condition and probably they played a very small part in the dissemination of the fungus. The facts of dissemination could not be actually proved as most of the palms were from 20 to 40 feet high and, so far as I was concerned, unclimbable, but the possibility and the likelihood are not in doubt. The facts of mycelium and spore development were demonstrated by having many of these leaves cut down by tappers and examined. These trees produced a varying number of spotted leaves, the largest number that has been counted on one palm being fifteen in the village of Achanta. As the palm produces roughly a leaf a month[2] these leaves would have offered one after another possibilities for the spread of infection for considerable periods. For example, a palm about 30 feet high was marked in the village of Annampalli in Godavari District in August 1908 as having the laminæ of more than one leaf spotted and it remained alive putting out spotted leaves till January 1912 when the central leaves were noticed to be dead and the crown was cut and burned by a revenue inspector in my absence. I saw it twice in the interval and verified the presence of fungus in ten leaf-sheaths but unfortunately the

[1] McRae, W. Rows of Spots on the Leaves of Palmyra Palms. *Agri. Jour., India,* Vol. VII, pp. 272 to 279.

[2] McRae, W. Growth of the Palmyra Palm. *Indian Forester,* Vol. XLIV, pp. 25, 26, 1918.

number of spotted leaves was not counted at the end. This palm was thus known to have had the disease for three and a half years in a condition favourable for dissemination. Though the people acquiesced in allowing dead palms to be cut, they were extremely averse to having those with spotted leaves cut too. At first I wanted them to be cut and burned as dead trees were, but evidence was gradually accumulating to show that it was unnecessary to destroy them and that they could be saved.

My attention was first attracted to the possibility of a palmyra's recovery by seeing some palms that had recovered after they had been beheaded in the course of the ordinary operations. These new crowns were small and sometimes stuck out at an angle and did not often survive, but one in Itampudi grew well and was under observation for six years. It was cut in 1910 or 1911 and grew till 1917 when it succumbed to the disease, being situated in a most intensely infected part of the village. The trunk was constricted to half its diameter and then widened out to about the same diameter as below the constriction and elongated farther to about four feet. I thought that perhaps a new growing-point might have been formed from the slightly differentiated tissue round the growing-point or in the axil of a young leaf, but on carefully dissecting thirteen young cases I came to the conclusion that it was the original growing-point that had continued growth and produced a new crown. This was possible when the growing-point was not yet dead at the time of operation and the crown was lopped with an axe. As the crown fell over in a piece the uncut tissue was torn asunder and part of it was left covering and protecting the growing-point. In the delta I have seen two cases of branched palmyras, one with up to 30 branches, and two others in the other parts of South India, so there was no reason against a new growing-point being formed, but of this I could get no evidence in the cases examined. However, these cases did show that even after drastic treatment the palmyra had the power to recover, and this led me to consider the possibility of applying the same treatment to the outwardly infected palms to see in what number they would recover.

It was found in examining more than a hundred such palms, that when the fungus was penetrating the bud, which is from one to two feet in length, about the level of the growing-point, the base of the expanding leaf was penetrated and its tissue destroyed, resulting in the leaf withering and presenting the usual symptoms of disease, and as the fungus was in the vicinity of the growing-point the latter's death occurred within a short time. But when the fungus was penetrating the bud at a higher level, the folded laminæ of a young leaf was penetrated, and as it was developing actively it soon pushed

out into the air and expanded, presenting the symptom of disease consisting of a row of characteristic spots on the expanded leaf-blade and seeing the fungus was at a sufficient distance from the growing-point all the diseased tissue of the leaf-bases, petioles and laminæ could be cut off, leaving a mass of truncated leaves around the living growing-point. It was found by trial in several villages in different parts of the infected area, both in the delta and the uplands, that in any season, if this mass of tissue was four inches broad and six inches high the growing-point would not die but would in ninety-four per cent. of cases produce a new crown of leaves which in two years or more would be as large as the original crown. As soon as it became apparent that this kind of thing could be done, I tried the experiment on every occasion I could persuade the owner to allow me to operate on a case and as these trees began to multiply throughout the area, people began to see that there was some real tangible benefit in such an operation. So it became possible to have these trees treated and from February 1913 in Kistna District and July of the same year in Godavari District they were definitely included in the scope of the operations. In Kistna District where each revenue inspector's charge was smaller and lighter than in Godavari District the number of those outwardly infected palms dealt with in the first few months was large and ever afterwards comparatively small. In the latter district, however, the number was high and remained high for several months, thereafter coming down but always remaining substantial.

Simultaneously experiments were being made, whenever possible, in examining apparently healthy palms in the vicinity of dead and outwardly infected ones by cutting off leaf-bases, and it soon became apparent that a very considerable number that showed no outward symptoms were diseased. A few examples will suffice. In September 1910 at Vijheswaram, where dead trees had persistently appeared during the year, twenty-one were examined that all looked quite healthy : indeed the tapper said it was useless to climb them looking for disease. Ten had the disease, seven having living fungus and three dead fungus. The seven had 8, 9, 15, 22, 24, 25 and 29 leaf-bases spotted respectively and the three had 2, 3 and 7 respectively. About the same time at Rajabhupalapatnam forty apparently healthy palms were examined similarly in a field in which diseased trees were being cut, and fourteen of them had the disease. At Jagapatinagaram 203 dead trees were cut after the disease was discovered there in 1912. In October 584 healthy looking palms in the immediate vicinity were examined and 99 of them were diseased. At Siddhantham, in a part where trees were not climbed so much as usual, those round two dead and two outwardly infected palms were

examined and altogether thirty-four inwardly infected tall trees were discovered. These palms were not being touched by the operations till after a longer or shorter period of months they showed the outward symptoms. The record of the last mentioned example shows where infection begins. Disease spots were found in twenty-six trees to begin on the tenth or a lower leaf-sheath, counting upwards from the lowest leaf-sheath on the tree, in six to begin from the eleventh to the seventeenth and in two to begin on the twenty-first and twenty-fourth leaf-sheath respectively. By taking off ten leaf-sheaths seventy-six per cent. of the inwardly infected trees would be found and by taking off seventeen ninety-four per cent. Fifteen to seventeen was the number that came to be recommended for removal during the detailed examination to be described shortly. The number of leaf-bases on a palm depends on how often they are removed for economic purposes and how many are required at a time and varies from field to field and taluq to taluq. Even though a small number of infected trees would be missed, the omission was unavoidable. As it turned out, the inwardly infected palms were over a large area about 8 per cent. of those examined, and it would have been quite out of the question to have cut all trees so drastically as to have found out every case of disease.

To get information on a large scale a detailed examination of trees was made in the villages of Chikkala and Unagatla which are situated on the edge of the palmyra belt in the Kistna uplands where there is a great trade in sweet toddy for making *jaggery* for the sugar factory at Samalkota. Since the detection of the disease here in 1912, the number of dead trees had steadily risen and the area had increased to 1,059 acres. Great numbers of tappers migrated into this region annually from the central delta for the tapping season from March to June, and it is possible they brought the disease with them. At any rate their operations helped the disease to spread as the trees were so often handled and the tappers did not distinguish between infected and healthy palms in tapping. It was obvious that the extension of the disease into this belt would cause greater loss economically than in any other part of the area and that the operations here should be carried out more intensively. So great had been the opposition to the treating of outwardly infected palms in these two villages in 1913 that the Collector again suggested legislation to give authority to combat the disease. After a great deal of hard work in the villages the Special Tahsildar got a certain number of them done and towards the end of 1913 the Collector directed the Excise Officers not to issue any tapping licences during the coming season for trees situated in the infected area of these villages. At the beginning of the season in

1914 the agricultural and special officers concerned with the operations visited the villages and pointed out to the villagers that the disease was steadily spreading and would soon be into the heart of their tapping area and tha its progress could be checked if only they would co-operate in working against it instead of opposing the operations. It was consequently agreed that, if the villagers would cut and examine 17 leaf-bases from all the big trees and operate at once on all those found to be either internally or outwardly infected, then the prohibition would be withdrawn. To supervise the work all four Kistna revenue inspectors were concentrated in the two villages while the work was in progress, and an Excise Officer too remained to issue licences as soon as trees were ready. Work was finished before the tapping season really set in and tapping on trees known to be healthy proceeded. The result of the examination was as follows :—

Number of palms examined	Found to be diseased but with no external symptoms	Found to be diseased and showing external symptoms	Found to be dead
12,129	963	55	17

In May as the tapping season was on the wane the attention of the villagers was drawn to the results of this examination and to the likelihood of many of the palms that remained un-examined, because they were not ready or required for tapping, being infected and, if left alone, spreading the infection to the trees they wished to tap next year. They agreed to examine those as well, and all were examined with the exception of 450 palms infested with scorpions, snakes and "other devils" : these the tappers would not climb. The complete results of both examinations were as follows :—

Number of palms examined	Found to be diseased but with no external symptoms	Found to be diseased and showing external symptoms	Found to be dead
20,837	1,265	72	13

These figures showed that six per cent. of the palms were infected without showing external symptoms, and that in this area the improved operations of cutting and burning dead and outwardly infected trees were dealing with

only six per cent. of the total number of diseased trees actually on the ground at the time.

In December 1914 when I visited Unagatla I had ninety-seven of the trees that had been examined in the previous March re-examined in the two worst infected fields and found eight diseased. The figures for the examination in March in the two fields were as follows :—

Number of palms examined	Number inwardly infected	Number outwardly infected	Number dead
(1) 375	240	6	1
(2) 1,387	218	8	1
1,762	458	14	2

The result of my examination of these eight trees led to the conclusion that (*a*) two had been unavoidably missed as the disease began from the fifth and the ninth leaf-base, respectively, counting from the lowest on the tree, and eleven and thirty-three leaf-bases respectively were penetrated, (*b*) two were probably avoidably missed as the lowest leaf-base in one and the third, though exposed, leaf-base in the other were spotted and thirty-three and fifteen leaf-bases respectively were penetrated, (*c*) two had not had all the diseased tissue removed as they had been recorded as inwardly infected and outwardly infected respectively, and (*d*) two were infected during or shortly after the examination as the lowest leaf-bases were spotted and eleven and twelve leaf-bases respectively were penetrated. Two of them were outwardly infected in December and the other six had no outward symptoms. They would all have been discovered at a re-examination. Considering that this was the first time the examination had been done on a large scale, the work, though by no means perfect, was satisfactory from the point of view of materially reducing the disease.

The Special Tahsildar of Godavari District attempted a similar examination in the upland infected areas in June. He was not, however, aided by the fortuitous circumstances which so assisted work in Kistna. In the thirteen small isolated infected areas in the uplands sweet toddy tapping was of small importance and of course the licences had already been issued where required early in the year. The cost of examination was accordingly defrayed by Government, and eleven of the areas were examined. After

hard, patient work in the villages the Tahsildar presented the following result :—

Number of palms examined	Inwardly infected	Outwardly infected	Dead
11,327	570	382	88

The figures showed that five per cent. of the palms were infected without showing external symptoms, and that in these areas the improved operations were dealing with only forty-five per cent. of the total number of diseased trees actually on the ground at the time. This explained the slow action of the operations hitherto in vogue in combating the disease, when action was delayed till a palm developed outward symptoms, and made clear the desirability and the possibility of carrying out such an examination.

In 1914 the area under operation remained unaltered in both districts. The gradual change in the method of operations first by dealing with palms that were outwardly infected and then with those that were inwardly infected rendered it a little difficult to compare the figures for the several years. The total number of diseased trees dealt with in both districts was 82,831 and this was a little higher than the previous year, but of them only 36,357 were dead, a considerable reduction on the figures for dead trees of the previous year, *viz.*, 58,469. During the monsoon there was a very protracted spell of warm wet weather which was favourable to the spread of the disease. At Tanuku thirty inches of rain fell on forty-three days between July and September as compared with thirteen inches on twenty-nine days in the same period of the previous year. On the whole, therefore, the figures for the operations were satisfactory. The disease was discovered towards the end of the year in two adjacent villages in Tuni Taluq just beyond the previously known infected area. All the 2,373 trees in the infected area of 650 acres were examined and 172 were found to be diseased. There was a recrudescence of the disease in Bunder Taluq where thirty-nine diseased trees were found. In this year a marked improvement in the carrying out of the operations was definitely noticed during my tour in December when I inspected twenty-two villages carefully and saw only eight outwardly infected and no dead palmyras. This inspection revealed a very different state of affairs to what existed even two years before and showed that the special staff had been working well and acting promptly on every external indication of disease. The work was now being conducted effectively.

1915 was even a wetter year than the previous one; for thirty-two inches of rain fell from June to August as against the average for forty years of seventeen and a half inches. The total number of diseased trees dealt with in both districts fell by 24,000 and the dead trees by 14,000. As the monsoon ceased in 1914 the staff in Kistna was urged to attempt in the coming dry weather a detailed examination of all trees in some of the worst infected areas and responded by undertaking to make an examination of every infected village. This work, begun in the end of November, was carried on till June 1915. It was an uphill task demanding constant exposure in the field during the hottest and driest part of the year and taxed their energies very considerably, but they brought it off successfully and it was an excellent piece of work. Registers were prepared for every one of the thirty-one infected villages showing the fields in which any cuttings had been made in 1913 and 1914. Every tree standing in these fields was examined and also every tree standing in an adjacent field and being within fifty yards of an infected tree. Excluding the villages classed as uninfected but which were still patrolled and including similar villages in which examination had to be made because parts of the adjoined infected fields of other villages, this work was carried out in forty-one villages. Besides this a re-examination was made in the Chikkala area and extended to 1,789 acres as compared with 1,059 of the previous year with the following result :—

	Examined	Inwardly infected	Outwardly infected	Dead
Main area	139,302	9,504	707	373
Chikkala area	22,198	525	105	55
TOTAL ..	161,500	10,029	812	428

The figures showed the great step forward that had been taken in trying to get level with the disease. According to the system in vogue before 1913 only 428 dead trees would have been dealt with : according to that in vogue in 1914, 1,240 would have been operated on or three times the number, whilst by means of this detailed examination it had been possible to deal with 11,269 infected trees or twenty-six times the number that would have been dealt with under the original system. It must not be thought that during this examination we made sure that every infected palm in the area covered had been dealt with. There would always be some cases that were actually

missed or in which the work was done imperfectly or which though standing beyond the fifty yards' limit were yet inwardly infected. It must also be admitted that this examination exposed the susceptible parts of a great many trees to the risk of infection. The risk of passing on infection by means of the tapper's knife was avoided by having the knife sterilized in boiling water or by passing it through a flame, after the tapper had operated on a diseased tree and before he climbed the next one. But the risk of infection by beetles and by splashing during rain had to be taken. We hoped that because of the known slow rate of spread of the disease and because the work was done mostly in the dry weather, the rate of spread would be much less than the rate at which the trees were being dealt with. This was a weakness of the method but, if we had tried to protect the exposed surfaces with Bordeaux mixture or any other fungicide, the time taken to do so effectively with the staff at our disposal would have prevented the examination of the large number of trees contemplated.

Early in 1915 the Kistna Tahsildar, who had been in charge of the central delta for the previous two years, had examined 33,578 palms there and found 3,039 inwardly infected. To introduce this practice, however, over the whole of the main infected area in Godavari District was the biggest problem the special staff had been faced with since 1909 when the present system was introduced. The staff was strengthened very considerably in numbers and the work was begun when the harvest was over at the end of November 1915 in the eastern delta and the end of December in the central delta and was finished by June 1916, when the rains came. In all 384 villages were worked over and the cutting and burning was done entirely at the people's expense. They were encouraged to take a personal interest in the operations and to give help. The following were the figures :—

Examined	Inwardly infected	Outwardly infected	Dead
968,492	44,391	10,145	14,207

The relative proportion of the groups of figures was quite different from that found in Kistna District but that was not unexpected over the main area with all its varying degrees of intensity of the disease in different villages and where the relative proportion of area lightly infected was far greater than in the area worked over in Kistna. It did demonstrate, however, the tremendous advantage of the new method.

1916 was a wetter year than ever and far exceeded the record for the past forty years. This lowered the cuttings for the second half of the year simply because of the difficulty of getting trees cut and burned in very wet weather. In the first half a re-examination of the Kistna area was made and a third examination of the Chikkala area. This time palms were examined within fifty yards of all dead and outwardly infected ones that had appeared since the previous detailed examination. The figures from December 1915 to June 1914 were as follows :—

	Examined	Inwardly infected	Outwardly infected	Dead
Main Kistna area	24,419	1,150	302	310
Chikkala area	8,864	167	71	12
TOTAL ..	33,283	1,317	373	322

In the Chikkala area there had been a continuous drop in the number of inwardly infected trees in the three examinations and also in the total number of diseased trees found in the year, *viz.*, 1,570 in 1914, 1,110 in 1915 and 301 in 1916, so that the detailed examination seemed to be having an effect in reducing the number of diseased palms in this area. In the main Kistna area too the number of inwardly infected palms was less in the re-examination. After finishing this work the staff cursorily inspected forty-three villages eliminated from control during the last few years and found diseased trees in four of them. These were taken under control again and another was added later on.

During 1917, 1918 and 1919 the general examination went on during the dry months and the number of diseased palms decreased except in 1918 when it suddenly increased. This was a bitter disappointment. Even though there had been a series of unusually wet years we hoped that the operations now had a greater influence on the disease than natural conditions. In Kistna District the disease appeared again in thirty-seven villages that had been given over to the supervision of the ordinary revenue staff in 1912, and in twenty-one other villages in Bhimavaram, Kaikalur and Gudivada, and a few stray cases were cut at Bezwada, Ellore and Masulipatam, while in Godavari District a few cases were cut in Polavaram. This shows the insidious character of the disease and how difficult it is to eradicate entirely from a village. From March 1918, when the number of infected trees was greatest, a special effort was made to get the disease again under control, and the general examination

in 1919, when the staff tried to find every diseased tree, showed that the number had fallen again to previous proportions. In December 1919 and January 1920 my assistant Mr. Sundararaman and I toured by separate routes through the worst infected villages of both districts. Altogether we saw under thirty dead or outwardly infected palmyras even though operations had been suspended for the previous two months. In former years during December and January there had always been a large number of diseased palms and we expected to see several hundreds. That so small a number of diseased trees was found on this tour of inspection was very encouraging and was an undoubted proof of the success of the operations.

From November 1919 to March 1920 the operations were suspended at the instance of the Director of Agriculture in order that the staff might carry on a campaign of publicity before the application of the Pest Act to the disease. It was in connection with the attempt to have outwardly infected trees dealt with that we first suggested early in 1912 to take legislative power to cut compulsorily such trees, but Government declined to resort to compulsion till the need for it was much more clearly established. The operations went on accordingly relying on the tact and persuasiveness of the members of the special staff to overcome the difficulties. That they were successful in great measure has been shown in the discussion of the position of the operations from year to year, but they never induced any great body of the tree-owners to do the work spontaneously though they did persuade them to allow the cutting to be done at their (the tree-owners') expense. By 1919 a definite proposal for a local Pest Act was accepted by the Government of Madras, and at a special meeting at Pusa, where the subject was discussed, the last objection to such an Act was withdrawn and the way was finally opened for having it passed. Throughout the whole period of the operations there was one hope that never was realized to any great extent– the hope of interesting the tree-owners in the measures taken to combat the disease to such an extent as to get them to act for themselves. Had this hope been realized the special staff might have been withdrawn gradually and the people left to protect themselves against loss from the disease. Most people in the infected area knew about the disease and its symptoms but entirely depended on the official staff to deal with it. The next step was to stir up this interest. By the application of the Pest Act of 1919 dealing with diseased palmyras became a duty, and it seemed not unreasonable to believe that after people got accustomed to tackling the disease themselves they would come to realize that they could fight it without extraneous help. To ensure that every person in the infected area and around it did know sufficient about the methods

of dealing with diseased trees, his duties under the Act and the penalties for non-compliance, the special staff stopped the operations and devoted themselves to a publicity campaign. The fact of the operations being entirely stopped for four months seemed to have impressed the people that Government was in earnest. Pamphlets in the vernacular were written with illustrations given in colour and distributed to all the literate people directly and indirectly connected with the villages and small posters with an illustration of a diseased palmyra palm were posted in thousands on conspicuous places. To reach the great bulk of the tree-owners, who were illiterate, meetings were held in the villages where "sandwichmen" were sent round by day and lantern demonstrations were given by night. Verses were written and folksongs adapted and they were sung at festivals and fairs and mask dances were also a feature. Everything possible was done to excite interest and there is no doubt of the success of the campaign, and the credit is in great measure due to the energy and fertile brain of M. R. Ry. Rao Saheb V. Bhogappayya Sastry Garu, B.A., Special Deputy Collector on Palm Duty in Godavari and Kistna Districts.

In 1920 and 1921 when the complete operations were being carried on with the additional stimulus of the Pest Act, the number of diseased trees found remained low, being 16,500 in 1920 and 8,700 in 1921.

General review of the operations.

(a) *The numbers.* The earliest attempt in 1906 to deal with the disease over a limited area accounted for 40,000 dead palms. The number of dead palms cut during the 19 months, June 1907 to December 1908, *viz.*, 398,000, included many trees that had died from about June 1904 because it takes up to three years for all the leaves to wither, reckoning from the time the growing-point dies and the topmost leaf has withered. Consequently a considerable number of such cases would still be standing and be dealt with by the staff as they moved over the infected area. As mentioned on page 47, the intensity of the disease was greatest in 1908 when probably about 100,000 died, even though 183,000 were actually cut that year, the excess being cases that had died in the years immediately preceding. From 1908 to 1913 there was not much of a fall in the annual figures, this being due to the gradual perfecting of the operations, to trees being cut more promptly and to the area being better patrolled. From 1914 to 1917 there was a steady fall in the number of outwardly diseased and dead trees owing to the fact of 74,800 inwardly infected trees having been dealt with and cured. 1918 was a disappointing year because the number suddenly rose in all categories. However, there

PLATE II.

10 Miles
Polavaram [13 Villages] Taluk
Kovur
Yernagudem Taluk
Vijheswaram
Chikkala Unagatla
Ellore
Kolair Lake
Bezwada
Tanuku Taluk
Siddhantham
Bhimavaram Taluk
Kaikalur Taluk
Gudivada Taluk
Bunder Taluk
Kistna District
Masulipatam
Kistna River
Tenali [6 Villages]
Repalle [2 Villages]
Divi Taluk
To Bhadrachalam
Jagapetinagaram
Pittapur [2 villages]
Tuni Taluk [6 villages]
Rajahmundry
Rajahmundry
Cocanada
Cocanada
Mundapeta
Karapa
Ramachandrapur
Ramachandrapur
Taluk
Taluk
Gautami Godavari
Kottapeta
Vasishta Godavari
Annampalli
Achanta
Amalapur
Itampudi
Amalapur Taluk
Narsapur
Razole Taluk
Narsapur Taluk
Nagaram Island
Godavari District
BAY OF BENGAL
.... Infected area in 1905
..... " " 1908.
..... " " 1910 and subsequently
The brown area contiguous with the red plus part of the brown area in Bunder and Gudivada Taluks is the area that was known to be infected in 1910.

was a considerable fall in 1919. In 1920 the Pest Act was applied and the numbers again fell both in that year and in 1921, the last year of the operations under review. From 1913 onwards 100,000 diseased trees in the early stages of infection had the diseased tissue removed and were restored to health during the examination of 2,800,000 apparently healthy palms growing in the vicinity of dead ones, and there can be no doubt that this had a great influence in quickly reducing the number of dead palms in the later years of the operations.

(b) *The area.* The area said to have been infected in the earlier years was given by Dr. Butler for August 1905 [1] and for the end of 1908 [2], and in a report to Government I gave the known infected area about the middle of 1910. The diagram (Plate II) shows in colour the different areas which were about 500, 1,200, and 1,800 square miles respectively. The extension in the northern part is fairly accurate but that towards the Kistna is inadequate in all three estimates. The information in the earlier estimates was got chiefly by a young member of the Agricultural Department whose home was in the Godavari delta, and it is likely that he had more detailed information about the Godavari where his home and his work were than about the Kistna District. The people in Tanuku and Narasapur Taluqs say they noticed it in 1903, the year of the cyclone, but the people beyond the Narasapur canal had no reason to report the presence of disease in those early days, thus it could only be located by actually seeing it and there was little or no touring done in the Kistna District before 1910 with the object of finding the extension of the disease. With later more accurate and detailed knowledge of the disease in this locality it seems more than probable that long before 1905 the disease had already crossed the Vasishta branch of the river, and that it had extended further into Kistna District by 1908 or by 1910 than is shown in the map. Early in 1910 cuttings were being made in Bunder Taluq around Masulipatam and from observations on the dead palms there I am certain the disease had been there for over three years before this date. Yet at the end of 1908 the disease had not been reported, nor was it known to exist there, by members of the department. In 1910 there were only two infected localities known between Masulipatam and the infected area in Narasapur and Tanuku Taluqs adjacent to the main infected area in Godavari District, *viz.*, Gudivada near the former area and Kaikalur near the latter. Hence I was inclined to think that the disease had been carried to Masulipatam by sea by human agency, which of course was quite possible. Subsequent information got by the

[1] Butler, E. J. *Agri. Jour. India*. Vol. I, pl. XX, p. 305.
[2] Butler, E. J. *l.c.* opposite p. 221.

Special Deputy Collector and Tahsildar, by one of my assistants and myself in extensive tours have led me to think that this explanation is unnecessary and that the disease could have travelled overland from the Godavari area. Granted that Kistna was infected earlier than was at first thought, and this seems very likely, the overland extension is quite feasible and in conformity with the facts of the then better known extension northwards in Godavari. The boundaries of the infected area about the end of 1912 enclosed a total area of about 4,000 square miles and, with the exception of two small extensions along the coast at the extreme ends, comprise the limits of the infected area. Beyond the railway line from Rajamundry to Samalkota and Cocanada the land is not irrigated but is upland dry land of a slightly undulating nature. Here the extension has been slow and the disease has generally occurred in the shallow depressions. From quite early in the operations efforts have been made to banish it from this tract and with success. It is now confined to two small tracts near the railway line and one further up the coast. In one of the former round Rajamundry the disease is of long standing and is still intense. This has come about because the tree-owners there have all along been difficult to persuade to do anything or allow anything to be done, but the stimulus of the Pest Act will no doubt have the desired effect. The tract in Peddapur consists of two very small areas where very few diseased trees are found now. The tract along the coast in Tuni Division comprised parts of two villages in 1914 but later was found to extend to eight. It was outside the area patrolled and had the disease for some time before it was discovered, but work is being concentrated on it now. Beyond the railway line from Rajamundry to Bezwada the disease, so far as is known, has not appeared except in a few villages on the right banks of the Godavari river once believed to be free but now known to be still infected. It has actually reached Bezwada and Ellore halfway between the two as an extension from the delta. The Kistna river is the boundary on the west side except for two small areas near Repalle and Tenali which were discovered in 1920 beyond the patrolled area. They are now being dealt with thoroughly.

(c) *Intensity of the disease.* The Kistna area was never so intensely infected as the Godavari one, with the exception of those parts of Tanuku and Narasapur Taluqs between the Narasapur canal and the Vasishta branch of the river, and has been more amenable to treatment by the operations. The disease is in several isolated areas and is nowhere severe except perhaps comparatively so in the river-side villages. Though not to the same extent as in Kistna the disease has disappeared throughout the Godavari District from many places where it once existed, and there are still five areas in which

it is severe though nothing like to the same extent as formerly, *viz.*, around Rajamundry, Mundapeta, Karapa, Vemavaram and Kottapeta. In general the disease has been pushed out and kept out of the uplands around the deltas except to a short distance on the banks of the Godavari river and in two other small areas, while in the deltas it has been thinned out especially towards the Kistna side and reduced in intensity.

(d) *The Cost.* The total expenditure in connection with the operations from 1906 to 1921 has been in round figures three lakhs of rupees or £20,000.

Results of the operations.

As in every fight against a disease it is well nigh impossible to make a complete estimate in figures of the good that has accrued, for besides the definite arithmetical value that can be put upon the individuals that have been cured, there remains the value of those that have escaped taking the infection because of the protection given them through the preventive measures, and any estimate of this value is more or less speculative. The capital cost of a palmyra in the deltas is about two rupees on the average. The benefits of the operations may be stated under four heads. (*a*) The value of the palms that have been cured, taking the number as a conservative estimate at 90 per cent. of 231,631 "inwardly" and "outwardly" infected palms operated on, is 417,000 rupees. (*b*) In 1907 and 1908 the number of dead palms cut includes the accumulation of several years, but in 1909 the bulk of the old standing cases had been removed and the operations would have had some little effect in reducing the yearly number of dead palms, so 100,000 may be taken as representing the maximum intensity of the disease in 1908. Now if the disease had continued steadily at that intensity then in the 15 years of the operations 1,500,000 palms would have died. But during that time 758,000 died,[1] so it can be said with confidence that 742,000 have been saved from infection and these represent a value of 1,484,000 rupees. (*c*) Again from the number of dead palms that were cut in 1907 and 1908 (398,000) it is clear that the intensity of the disease had been increasing rapidly since 1890 when it was first noticed, and there was no reason against its going on as rapidly to increase in the next 13 years. Besides, from an analysis of the figures from June 1907 when the operations began to the end of 1908, together with the knowledge that an interval of three and a half years may elapse between the death of the growing-point and the withering of all the leaves of

[1] Dead trees cut—calculated accumulation of dead trees in 1907—8 or 956,449—189,329=758,120.

the crown, and that the disease arose to epidemic dimensions from a definite place in the Godavari delta about the year 1890, we can assume a simple progression in the rate of increase; then the figures for

	1908 would be	100,000
	1907	94,000
	1906	88,000
	1905	82,000
and for ½ of	1904	38,000
		402,000

the total of which is very near the figure for those actually cut, *viz.*, 398,000. At the same rate of progression for the next 13 years the figures for dead trees would be about 1,790,000 multiplied by some factor comparable to 100,000, the number of dead trees in the beginning of the period of 13 years under consideration. Of course, the actual number is purely speculative, but it does show the nature of the proportions to which the disease was approaching. The prevention of the disease in this case has a potential value that cannot be accurately estimated in money. (*d*) In conclusion, we can affirm definitely that the disease has been reduced from a grave menace (100,000 in 1908) to a controllable factor (8,700 in 1921).

Though the disease has been greatly reduced it is still dangerous and requires to be treated with caution. So many times has it been found, more especially in the earlier years, that when a village was put out of the sphere of operations after it had shown no diseased trees for one year, and sometimes too in later years, after an interval of two or three years the disease appeared again, sometimes because of re-infection from outside but undoubtedly also from the appearance of a small number of cases in which the fungus had been developing slowly, consequently the disease had appeared after a longer period than usual and had again started a nucleus of infection that spread the disease to surrounding trees requiring the village to be brought under the operations once more. Hence the operations under the Pest Act will have to be continued for some years longer (1) to reduce still further the amount of disease and (2) to deal thoroughly and expeditiously with the three or four small outbreaks that have occurred beyond the hitherto patrolled infected area.

It was the influence the Collectors of the two districts and their subordinate officers had with the people that made it possible for these irksome operations to be carried on, the members of the special staff being recruited wholly from the revenue branch of the district administration. For years there was no

legal compulsion behind the staff and the only authoritative backing it had till 1919 was the order of the Collectors to the village officers to attend to this work. (Naturally it was Government in the first instance that decreed the operations, provided the funds for the special staff, and decided on the continuance of the work. But I am referring just now only to the actual working of the operations in the districts.) The revenue inspectors could not legally compel anyone to cut diseased trees, nor had they the right to enter on anyone's land and cut diseased trees. Everything had to be done with the acquiescence and the co-operation of the people, and naturally it took a considerable time to get them to agree at first to allow the work of cutting to be carried on at Government expense and then gradually at their own expense, especially as for some years there was no very apparent good result and as they believed the disease to be the scourge of a malign deity which there was little use trying to escape. It reflects credit on the members of the staff that they did so much for so long without any person's taking proceedings against them, and again that the people have been induced to carry on the work during the last two years under the Pest Act with only one prosecution. That the credit for carrying on the operations against this disease with the measure of success achieved is due to the special staff under the direction of the Collectors of the two districts is freely acknowledged. The Agricultural Department's activities consisted in elucidating the life-history of the fungus, devising and improving methods of combating the disease, and giving encouragement.

Occurrence of bud-rot of the palmyra in other parts of India.

One of the Special Tahsildars, who, when he was transferred from special duty on the palmyra disease operations in Godavari District, was posted to Bhadrachalam about 100 miles up the Godavari river, assured me that he had seen the disease among palmyras there. He knew the symptoms of this disease well and can hardly have been mistaken. The locality was difficult of access and I never had the opportunity of visiting it, nor did I manage to get specimens, so the observation was not confirmed. If it does exist there it suggests the interesting speculation that it may have come down the river and become epidemic in the delta after the completion of Sir Arthur Cotton's great irrigation scheme about 1854 had changed the delta and its environs into double crop wet land. Even[1] before the building of this irrigation system certain portions of the delta had been irrigated, but the area was small

[1] *Gazetteer of the Godavari District*, Chapter IV, p. 85.

and the channels were open only for about fifty days in the year during floods, so that the soil conditions of the delta were entirely changed after that date. If the speculation is correct the natural conclusion is that the palmyra in the deltas is doomed, and that, if it be left to the play of natural influences, it

will simply be a case of time before it becomes scarce. Even so the operations would have been well worth the labour and expense in order to prolong the time of decline and allow the coconut palm to be planted in sufficient numbers to replace the palmyra in the economic life of the people.

Outside the Godavari and Kistna area bud-rot in palmyra has been found in Peruvaje in South Kanara District on the West Coast and in Hooghly District of Bengal. Only a few cases were found in the former which is not far north of the area in Malabar where coconut palms are infected as will be mentioned later.

Occurrence in Bengal. While travelling by train to Pusa in 1921, Mr. S. Sundararaman, the Acting Government Mycologist of Madras, noticed between Calcutta and Burdwan in Bengal many palmyra palms dying and dead of a disease suspiciously like bud-rot. This was confirmed on examination. The following information has been acquired during tours made by a mycological

assistant from Pusa and a member of the Department of Agriculture of Bengal. The disease has affected palmyra palms only. It extends at its widest limits from Dankuni, ten miles north of Calcutta, to Gangpur near Burdwan, a distance of 50 miles, and from near Dwarhata to Inchura, a distance of 28 miles, while the infected area is approximately 700 square miles. Palmyras however, are comparatively few in this region. Along with mango trees, bamboos and coconut palms they grow on the numerous slightly elevated pieces of land which are the village sites and between which stretch wide expanses of rice fields where palmyras do not occur on the raised boundaries between fields as they do in the Madras Presidency. Because of this discontinuous distribution of palms within the area it is perhaps unlikely that the disease will spread so fast or so persistently as it has done in the south; Nor is the palmyra so valuable a tree in the Hooghly District either for thatching or for fuel, and it is said to be but seldom tapped for toddy. Economically the loss of palmyras is not thus of very much importance within the area at present infected, but it is a matter for consideration whether the damage would not be considerable were the disease to spread much or become epidemic. The number of dead trees is not known as no measures have yet been taken to deal with the disease. Assuming that the fungus runs its course as it does in Godavari and Kistna Districts, then from the appearance of palmyras in such villages as Pandua and Gurup I think the disease has been present for at least five years, and the people say that deaths have taken place in greater numbers for about that period. Considering the area now known to be infected, it is, however, probable that the disease has been present for a much longer time. Soon after the disease was discovered here the Madras Department of Agriculture had the palms of the maritime villages of the districts north of the infected area of Godavari District examined for a distance of 240 miles to the frontier of Bihar and Orissa, but no diseased palms were found. There is thus no thought of the disease having spread northwards by land into Bengal from the Godavari District. It is possible for it to have been carried by sea but the infected area is too large to get reliable information as to where it started. On the other hand, it is possible that the disease is endemic. Its presence was brought to notice by an officer who was closely connected with the disease in Madras Presidency, and it was till then unknown to the Department of Agriculture though the fact that palmyras were dying in considerable numbers in this and other parts of the delta and its environs was known as early as 1912. This shows that the disease has hitherto caused no appreciable loss, and that the people are so accustomed to palmyras dying in small numbers as to pass it without comment. All this rather

indicates that the disease has been present for a considerable time, than that it is of recent introduction.

Occurrence of bud-rot in the coconut palm.

In Godavari and Kistna Districts the number of coconut palms, *Cocos nucifera* Linn., is few indeed compared with that of palmyras. Round Amalapur and Ramachandrapur, however, they are increasing and are being planted in gardens of fair size. Very few cases of this disease, however, have occurred amongst them. In this area, compared with the 700,000 palmyras that have been found to be diseased since January 1910, when I took over the post of Government Mycologist, Madras, not more than 200 coconut palms have become diseased. When the fungus is placed on the pale yellow soft susceptible part of the bud of a coconut palm it penetrates as readily as in a palmyra. The relative freedom from disease of this palm is not therefore due solely to resistance in the palm but mainly to the structural character of the bud and to the fact that the palm is less handled than the palmyra. The leaves of the coconut palm grow out at an acute angle to the imaginary upward prolongation of the stem, gradually bend over and ultimately hang down. Quite early as the leaf-base becomes gradually exposed its protective covering becomes so thickened as to be only with difficulty and usually not at all penetrable by the fungus. On the other hand, the leaf-base of the palmyra always remains in its original position, literally as a sheath, one to one-and-a-half or even two feet long, and its protective covering does not thicken materially for many months, till it becomes exposed by the removal of the leaf-bases below it. From the time a coconut leaf protrudes from the bud and expands, to the time it is at right-angles to the stem and its leaf-base is non-infectible, a period of 10 months usually elapses; whereas from the time a palmyra leaf expands till the leaf-base is exposed and is non-infectible, a period of three years may elapse. During these intervals and of course for some time before when it is in the bud each leaf-base is infectible. There is a stiffness about the palmyra with its more rigid trunk and the broad simple laminæ of its leaves that must cause the softer inner tissue of the parts of the bud to be momentarily exposed as the crown sways in the strong winds of the monsoon and so allow of the possibility of infection to be relatively greater. The coconut palms in the deltas are seldom tapped for toddy and are climbed only for harvesting the nuts and for removing the leaves for thatching purposes and making mats. At neither time is the bud cut. Palmyras, on the other hand, are frequently tapped and are always prepared for this by cutting off the lower leaf-bases to trim the tree; the leaf-bases

are also removed at short intervals for fuel and to some extent for fibre. Thus the palmyra is handled more frequently and in such a manner as both to expose it to infection and to cause infective material to be carried to it.

Occurrence of bud-rot of the coconut palm in other parts of the Madras Presidency.

Early in 1913 Mr. T. Bainbrigge Fletcher, then the Government Entomologist of Coimbatore, brought to notice the occurrence of bud-rot in coconut palms in a village near the foot of the Tambarasseri ghat in Malabar District facing the West Coast of South India, and the cause was determined by Shaw and Sundararaman[1] to be *Phytophthora palmivora* Butl. A special staff of revenue inspectors was organized to search for the disease in this part of the district to determine its extent and to have the diseased palms operated on or destroyed as was required. During the monsoon which was heavy in this locality they examined gardens and marked infected trees to be dealt with in the ensuing dry weather. In the course of the work extending over two years the disease was found in 102 villages in seven taluqs. Calicut, Chirakkal and Kurumbranad had the greatest number of infected villages, *viz.*, 44, 27 and 22 respectively, while Ernad and Kottayam had 5 and 2 respectively. In one village of Ponnani Taluq and another of Cochin a few diseased palms were found and these, as far as was discovered, were far away from the main infected area. The symptoms on coconut palms were similar to those on palmyras, *viz.*, the dying of the central leaf and in succession those below it, the appearance of characteristic rows of spots on the pinnæ of the leaves and on successive leaf-bases and the rotting of the bud. As far as possible trees with either of the outward symptoms were dealt with but very great opposition was encountered to cutting those with rows of spots on the pinnæ. As far as the experience went, the coconut palm did not recover nearly so readily as the palmyra under similar drastic surgical treatment. The number of trees dealt with was as follows :—

Half-year ending December 1913	877	palms cut.
June 1914	1,680	,, ,,
December 1914	688	,, ,,
June 1915	1,183	,, ,,

Besides which, 75 that were located were dealt with by the ordinary revenue staff soon after. The total number was thus 4,503 in about two years. The disease was very widely spread in that part of Malabar District

[1] Shaw, F. J. F. and Sundararaman, S. The Bud-rot of Coconut Palms in Malabar. *Ann. Myc.*, Vol. XII, pp. 251-262, 1914.

but was nowhere intense. The fruit of this palm is so valuable that it was practically impossible to get the people to apply the system of detailed examination of palms growing within fifty yards of the diseased ones as was done with the palmyras in Godavari and Kistna Districts. The location of the disease and the small number of trees attacked seemed to indicate that the disease had been there for many years and that it was not increasing. The comparatively costly special staff was accordingly disbanded and the work was entrusted to the ordinary revenue staff of the district. Illustrated leaflets in English and Malayalam were distributed in large numbers describing in detail the symptoms of the disease and the remedial measures to be adopted. The revenue staff was also impressed with the necessity of giving early intimation of the disease becoming acute in any locality. Since then only a small number of trees have been cut and nowhere has the disease become severe.

The disease has also been found on coconut palms at Conjeeveram in Chingleput District, at Gudiyatam in North Arcot, at Ernaculam in Cochin State and at Alleppey in Travancore State. In all these places very few diseased trees were found (under fifty in any place). Conjeeveram and Gudiyatam are small isolated areas hundreds of miles from the other known infected areas. While of the extent of the disease in Cochin and Travancore States the writer has no information. The fact that the disease exists without doing much damage over a considerable range of the West Coast where there is a continuous belt of coconut palms from south to north seems to indicate that it is endemic in South India. This disease was also found on young coconut palms in a garden in the town of Madras. The garden owner had himself brought the seedlings from a village within the infected area in Malabar and planted them in his garden. Fortunately when the disease appeared he asked advice from the Agricultural Department. It was at once diagnosed and all the palms were destroyed. Neither before nor since has the disease appeared in the vicinity of Madras. This is a proved instance of the disease having been carried for a distance of four hundred miles by human agency.

Spread of the disease.

So far as has been demonstrated the fungus is carried from tree to tree by means of tappers, and rhinoceros beetles, *Oryctes rhinoceros* Linn. The rhinoceros beetle is the commonest of the insects that visit the palmyra. The adult beetle alone is found in living crowns boring into the stalks and lamina of the younger leaves near the apex of the crown and feeding on the tender tissue. The earlier stages, egg, grub and pupa, are met with only in dead and rotting crowns and in rotting stems and, of course, also in garbage

elsewhere. The habits of the beetle are thus such that it could be a carrier of the disease from palm to palm. Besides it is also likely that during the monsoon the spores are splashed from the spots on an expanding leaf to surrounding palms. The transference of spores and mycelium of the fungus from an infected tree to a healthy one has been made by means of a platinum needle, a scalpel, the leg of a rhinoceros beetle, the finger and a tapper's knife, and trees have become infected in all cases.

In ordinary conditions the tapper's knife is one of the chief means of spreading the disease. When he cuts a tree in any stage of disease either during the operations or in the course of his business he is likely to get the fungus on his knife or his hands and to leave it on an infectible part of the next tree he climbs. This has been done in many villages while demonstrating to the assembled tree-owners that the disease could be spread in this way. The tapper inserted his knife into a spot on a leaf-base and then drove his knife a few leaf-bases deep into a crown or cut off some leaf-bases. The tree was marked and was not climbed till our next visit. Invariably the palm had produced the characteristic spots on the leaf-bases a few months afterwards when it was examined in the presence of the villagers. For example, one palmyra was pierced in two places. When examined the leaf-bases were found to be diseased as follows: counting from below upwards leaf-bases Nos. 1 to 4 were free, 5 had a spot on the inside of one limb, 6 had a knife-cut and a spot surrounding it, 7 to 15 had spots, 16, 17 and 19 had knife-cuts one within the other and from them had started a new set of spots that increased rapidly in size to the 26th and 27th leaf-bases where the spots were from three to four inches in diameter, 28 had a smaller spot and 29 had a small spot on its outer surface, while 30 to 33 had no spots. After thus removing the leaf-bases for examination the tree recovered and was healthy for the next three years. In recognition of this tappers were taught to sterilize their knives after cutting a diseased palmyra either by passing the knife through the flame of the burning crown or by rubbing it well with dry earth, and during the detailed examination of trees growing round diseased ones the tappers, under the supervision of the revenue inspectors, were trained to flame their knives or to place them for a minute in hot water.

In July 1911 the crowns of five young palms were enclosed in cages made of fine wire mesh. A rhinoceros beetle was caught and made to crawl over a culture of the fungus that was discharging zoospores. It was found on examination that it had a considerable amount of mycelium and sporangia as well as zoospores on its under surface. It was placed on the crown of one of the palmyras in the cage. This was repeated with other

beetles on other three palms. The same was done with two pairs of palm weevils which were placed on the crown of the fifth palmyra. None of them made any attempt to bore but crawled up and down the cage till they died. The experiment was repeated : only this time a part of a leaf-sheath with a pale yellow lower part was removed from each palm and the beetle imprisoned in its place. More weevils were not available at the time. At the end of September the five palms were examined. The fungus had developed in four but not in the fifth. From two to eight leaf-sheaths were penetrated. Three of the weevils were recovered dead in the position in which they were placed while two had disappeared. The diseased leaf-sheaths and four more were removed and trees were alive and healthy several years afterwards. The cages were removed and placed on five other palmyras and the experiment with rhinoceros beetles repeated with similar results except that all five became infected. The diseased leaf-bases were completely removed and those five remained free from disease afterwards. It was done in a field in which diseased palmyras had never occurred, and I did not wish the palms to die lest the people would be annoyed and disagreeable with regard to the operations, hence the disease was removed from them in order that they might not die. The fact that I wanted to demonstrate was whether an infected rhinoceros beetle could carry the disease to a healthy palm and it was done. Beetles have been caught and examined several times but only once has the fungus been cultivated from one. The beetle exists in considerable numbers and many palms are bored, so I believe it plays an appreciable part in the dissemination of the disease.

The red palm weevil, *Rhynchophorus ferrugineus* Oliv., found on the palmyra but more common on the wild date palm, passes all its stages on the palm. It is generally believed that the weevil attack follows that of the beetle, the holes made by the latter offering favourable spots for the weevil to lay eggs in. I have found it seldom and then on young palmyras only when, after the leaf-bases have been cut, they began to bleed a sweet juice. Its numbers and habits thus lead one to believe it plays an insignificant part, if any, in spreading the disease.

The disease travels slowly though persistently and the three means of dissemination discussed, namely, tappers, rhinoceros beetles and rain splashing on the expanding infected leaves, together with occasional long distance transport by human agency seem sufficient to account for the facts.

II. INOCULATION EXPERIMENTS WITH *PHYTOPHTHORA PALMIVORA* BUTL. ON *BORASSUS FLABELLIFER* LINN. AND *COCOS NUCIFERA* LINN.

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Series **A** was carried out with the fungus taken direct from the palm and pure as tested by the microscope, while series **B** was done with pure cultures of the fungus.

A. The crown of a palmyra in which the central leaf was becoming pale was cut off in Rajabhupalapatnam in the morning of 17th July 1910 and brought to Samalkota in the afternoon. The outer leaf-sheaths were removed till clean young spots were exposed on the inner leaf-sheaths, and several of the spots were cut out and placed in a moist chamber. Next morning the spots had a copious growth of mycelium on their surfaces. Small pieces of aërial mycelium were examined microscopically both before and after producing sporangia and appeared to be a pure growth. When the material was placed on a glass slide and irrigated the numerous sporangia burst and within an hour most of them had discharged their zoospores. This was the material used for inoculating palms Nos. 1 to 14. The water from such cultures was carefully washed into a watch glass and a drop used for Nos. 15 to 17. Young palms, the visible part of whose trunks varied from three to twelve feet in height, were selected in a field in Bhimavaram near Samalkota, the only criterion of choice being that they were small enough to be operated on from the ground or from a tapper's short ladder. The outermost dry leaf-sheaths were removed and the inner partially dry ones had the attachment of one limb to the stem severed, while the attachment of the other remained intact. Usually three or four leaf-bases were treated, thus giving access to the pale yellow living leaf-sheaths within. These half attached leaf-sheaths were held aside, the inoculating material placed on the outer side of the first

uncut leaf-sheath, and the half-attached leaf-sheaths replaced. A cord of fibre was tied round to keep the leaf-sheaths in position. In a few cases a fold or two of the fibrous material of the leaf-sheath was wrapped round and wetted but, as a matter of fact, in the result this made no difference. All the operations were done to one palm before proceeding to the next. The surfaces of the newly exposed leaf-sheaths on which the inoculating material was placed were not sterilized. But as the leaf-sheaths fit closely together and were exposed for only a few seconds, it is probable that they did not have any of the inoculating organism. The palms grew in a place in which it was known that diseased trees had not occurred within a radius of three miles. Spots from the inner leaf-sheaths of all of the palms that became infected developed, when incubated, aërial mycelium, sporangia and zoospores identical with those from the original palm. Seventeen palms were inoculated and all became infected. Three of them died but two had palm weevils in them so are doubtful. These two had exhuded a sweet juice from the stem where the limbs of the leaf-sheaths had been cut and so attracted the weevils. Seven controls did not become infected. All the diseased tissue as well as one or two more leaf-sheaths was removed from the palms in making the observation. Subsequently no diseased palm appeared in the field up to 1920.

Nos. 18 to 32 were done at Itampudi, and Nos. 33 to 50 at Kottapeta, both of which were severely infected villages. The infective material was similar and the method was also in most cases similar. A sterilized tapper's knife was sometimes used to place the fungus on the palm as a demonstration to the villagers. Sometimes the point of the knife which is blunt was laid against the leaf-sheath, at others the knife was driven into the crown for one or two inches. In a number of cases the limbs of the lower leaf-sheaths were not cut to get access to the inner ones but they were pulled down sufficiently far. No. 51 was a coconut palm done on the Samalkota Farm and described in Experiment III on page 67. Table IV gives a summary of the salient features of the inoculations. Of fifty palmyras inoculated, forty-eight became infected, of which seven died and two others that died had palm weevils in them. None of the nineteen controls developed symptoms of disease. The only coconut palm inoculated at this time also died. All the symptoms of disease seen in the field were reproduced, *viz.*, the death of the central leaf or group of leaves, the central leaf or group of leaves could be pulled out easily and had a discolouration and rot at their torn ends, spots on the leaf-sheaths, rows of spots on the laminæ of the leaves, and a rot of the bud which in advanced cases was stinking.

TABLE IV.

Results of inoculation of Phytophthora palmivora *Butl. on fifty palmyras and one coconut palm*

No.	Height of trunk in feet	Date of inoculation	Inoculating material	Date of observation	Interval of days	No. of leaf-sheaths attacked inwards	Central shoot dead	REMARKS
1	7	18-7-10	Myc. sporangia	18-8-10	30	2	..	The spotted leaf-bases were removed and the trees remained healthy. There was no diseased palm in this field up to 1920, the date of the last observation.
2	3	18-7-10	Do.	18-8-10	30	2	..	
3	9	18-7-10	Do.	18-8-10	30	2	..	
4	3	18-7-10	Do.	18-8-10	30	6	..	Do.
5	9	18-7-10	Do.	18-8-10	30	1	..	Do.
6	4	18-7-10	Tissue with Myc. sporangia	18-8-10	30	3	..	Do.
7	9	18-7-10	Myc. sporangia	17-8-10	30	10	+	Weevils present. Do.
8	4	18-7-10	Do.	18-8-10	30	5	..	Do.
9	9	18-7-10	Do.	17-8-10	30	11	+	Weevils present. Do.
10	10	18-7-10	Do.	17-8-10	30	10	+	Do.
11	4	18-7-10	Tissue with Myc. sporangia	18-8-10	30	5	..	Do.
12	4	18-7-10	Myc. sporangia	18-8-10	30	4	..	Do.
13	9	18-7-10	Do.	18-8-10	30	9	..	Do.
14	10	18-7-10	Do.	18-8-10	30	2	..	Do.
15	12	18-7-10	Do.	18-8-10	30	4	..	Do.
16	3	18-7-10	Zoospores	18-8-10	30	2	..	Do.
17	6	18-7-10	Do.	18-8-10	30	3	..	Weevils present. Do.

TABLE IV *contd.*

No.	Height of trunk in feet	Date of inoculation	Inoculating material	Date of observation	Interval of days	No. of leaf-sheaths attacked inwards	Central shoot dead	REMARKS
18	10	29-7-10	Zoospores	6-9-10	39	8	..	Destroyed during observation.
19	9	29-7-10	Do.	6-9-10	39	5	..	Do.
20	9	29-7-10	Myc. sporangia	6-9-10	39	6	..	Do.
21	10	29-7-10	Do.	6-9-10	39	4	..	The spotted leaf-bases were removed and on 23rd March 1912 all were healthy.
22	8	29-7-10	Do.	6-9-10	39	2	..	
23	6	29-7-10	Do.	6-9-10	39	4	..	Do.
24	8	29-7-10	Do.	6-9-10	39	3	..	Do.
25	7	30-7-10	Do.	6-9-10	38	4	..	Do.
26	11	30-7-10	Do.	1-12-10	124	8	..	Do.
27	4	30-7-10	Do.	1-12-10	124	..	..	Did not become infected.
28	8	30-7-10	Do.	19-12-10	142	11	+	
29	10	30-7-10	Do.	1-12-10	124	..	..	Did not become infected.
30	6	30-7-10	Do.	1-12-10	124	1	..	23rd March 1912. The infected leaf-sheath was dry and the fungus dead.
31	11	30-7-10	Do.	1-12-10	124	5	+	23rd March 1912. Dead.
32	7	30-7-10	Do.	1-12-10	124	9	+	Do.
33	8	9-8-10	Do.	2-11-10	85	..	+	
34	7	10-8-10	Do.	1-9-10	21	10	+	Leaf-sheath incised at inoculation.
	8	10-8-10	Do.	1-9-10	21	7	..	Crown cut off.

36	4	10-8-10	Do.	1-9-10	21	3	..	The spotted tissue removed and tree remained healthy.
37	11	10-8-10	Do.	1-9-10	21	2	..	Crown cut off.
38	6	10-8-10	Do.	1-9-10	21	8	..	Do.
39	8	10-8-10	Do.	1-9-10	21	2	..	The spotted leaf-bases were removed and the trees remained healthy for several years.
40	5	11-8-10	Do.	1-9-10	21	6	..	
41	7	11-8-10	Do.	1-9-10	21	6	..	Do.
42	5	11-8-10	Do.	1-9-10	21	5	..	Do.
43	6	11-8-10	Do.	1-9-10	21	4	..	Do.
44	8	11-8-10	Do.	1-9-10	21	6	..	Do.
45	5	11-8-10	Do.	1-9-10	21	4	..	Do.
46	6	11-8-10	Do.	1-9-10	21	4	..	Weevils present. Do.
47	10	11-8-10	Do.	1-9-10	21	3	..	The leaf-sheath incised at inoculation. Do.
48	12	11-8-10	Do.	1-9-10	21	8	..	Weevils present. Do.
49	9	11-8-10	Do.	1-9-10	21	3	..	Do.
50	8	10-8-10	Do.	25-11-10	107	..	+	Symptoms appeared between the 2nd and 25th November.
51	8	25-8-10	Do.	22-11-10	89	..	+	Coconut palm. [Expt. III. Table V.

A few examples may be given in detail.

No. 34. The four central leaves had become yellow.

The outer covering leaf-sheaths had

(1) four spots (3 × 2 in.), (1½ × 1 in.), ¼ in. and ⅛ in.

(2) two spots (5 × 4 in.), ¼ in. and ⅛ in.

Leaf-sheaths inwards from the inoculated place

(1) the inoculated spot was (5 × 2 in.), and an adjacent spot (1 × ¾ in.)

(2) one spot (3 × 2 in.), and two lower down (½ × ¾ in.), and (¼ × ⅛ in.)

(3) one spot (2½ × 2 in.)

(4) two spots (2½ × 1 in.), and (1 × 1 in.)

(5) one spot (4 × 1 in.)

(6) one spot (3½ × 2½ in.), a little below the level of that on 5.

(7) one spot (4 × 3 in.)

(8) two spots (1 × 1 in.), and (1 × 1 in.)

(9) two spots (1 × 1 in.), and (1 × 1 in.), one had a good web of mycelium.

These were at the insertion of the leaf-sheath and the tissue of the stem was discoloured and softer, but the leaves still within the bud were not discoloured.

No. 10. The three central leaves had become yellow.

The penetration of the leaf-sheaths was much the same as in No. 34, the discolouration and softening had extended into the bud leaves as well as being in the stem tissue.

No. 14. The infective material had been placed in the axil of the leaf. At the time of observation there was no outward symptom of disease. Two leaves towards the inside were penetrated and the soft tissue of the stem was discoloured and softened at some distance below the growing-point. Sections showed the presence of the fungus in the stem tissue and on incubating a piece mycelium and sporangia were produced. Cases of this kind have been found in nature and this is probably the reason for the occasional death of leaves lower than the central leaf as the first symptom.

No. 13. A thin slice of tissue with mycelium and sporangia was held on the upper part of the leaf-sheath and a fine jet of water played on it. At the time of observation there were no outward symptoms of disease. On the inoculated leaf were several spots at various heights penetrating through a

number of leaf-sheaths varying from two to nine in any one line. The fibre of the ninth leaf-sheath was discoloured and from the part of the discoloured area but not in line with any other line of spots a series of spots penetrated to the central expanding leaf going through its petiole.

No. 38 is typical of the others. Spots were found on one leaf-sheath towards the outside and on eight towards the bud in line. The spot on the outer leaf-sheath was 5 × 2 inches.

No. 1 had one spot 5 × 4 inches.
„ 2 „ „ „ 3 × 2 „
„ 3 „ „ „ 1 × 1 „
„ 4 „ „ „ $1\frac{1}{2}$ × 1 „
„ 5 had three spots 1 × $\frac{3}{4}$, 1 × 1 and $\frac{3}{4}$ × $\frac{1}{4}$ adjacent to one another and one spot on the edge of the other limb almost touching the others.
„ 6 had one spot $2\frac{1}{2}$ × 1 inches.
„ 7 „ „ „ 1 × $\frac{1}{4}$ „
„ 8 „ „ „ $\frac{1}{4}$ × $\frac{1}{4}$ „
„ 9 was clean and free from spots.

The eleventh leaf-sheath enclosed the bud and its lamina was the topmost expanding leaf. The spots on Nos. 5 and 6 had a felt of mycelium.

B. The palmyra and coconut palms used for inoculation had never been exposed previously to infection from the fungus. They were grown in Coimbatore which was fifty miles from the nearest infected area in Malabar District and was separated from it by a range of forest-clad hills running up to 5,000 feet. The trunk was measured from the ground level to the insertion of the lowest leaf-sheath of the crown and represents the visible part of the trunk. The cultures were made by plating aërial mycelium that had copious sporangia from a spot on a leaf-sheath and each culture was from a single sporangium. The controls were treated in exactly the same way as the inoculated palms except that no fungus was placed on them. The infective material for the inoculations was usually a small piece of mycelium from a subculture producing sporangia copiously and it was transferred by a platinum needle. The point of inoculation was usually recorded by a grease-pencil mark. The date given for the observation of the first symptom in Table V. is that on which the symptom was unmistakable.

TABLE V.

Inoculation experiments with Phytophthora palmivora *Butl.*

	No. on palm	Part of the palm inoculated	Date of observing first symptoms	Interval of days	Infected	Dead	First symptom
Experiment I	1	Leaf-sheath	21–12–13	15	+	+	C
	2	Do.	21–12–13	15	+	+	C
Palmyra to palmyra	3	Do.	21–12–13	15	+	+	C
Trunks 2 to 8 ft. high	4	Do.	21–12–13	15	+	+	C
Date of inoculation, 6th	5	Do.	21–12–13	15	+	+	C
December 1913	6	Central leaf	21–12–13	15	+	+	C
	7	Do.	9– 1–14	34	+	+	R
	8	Do.	..	..	–	..	..
	10	Do.	26–12–13	20	+	+	R
	9	Controls	..	..	–	..	..
	11 to 18	Do.	..	..	–	..	..
Experiment II	9×	Central leaf	..	..	–	..	..
	10×	Do.	11– 8–14	13	+	..	R
Palmyra to palmyra	11×	Do.	..	..	–	..	..
Trunks up to 4 ft. high	12×	Do.	13– 8–14	15	+	..	R
Date of inoculation, 29th	13×	Do.	11– 8–14	13	+	+	R
July 1914	14×	Do.	11– 8–14	13	+	+	R
	15×	Do.	..	..	–	..	..
	16×	Do.	10– 9–14	43	+	..	C
	17× to 20×	Controls	..	..	–	..	..
Experiment III	31	Central leaf	15– 8–14	19	+	..	R
	32	Do.	15– 8–14	19	+	..	R
Palmyra to coconut palm	33	Do.	6– 8–14	10	+	+	C
2½ years old	34	Do.	15– 8–14	19	+	..	R
Date of inoculation, 27th	35	Do.	15– 8–14	19	+	..	S + P
July 1914	36	Do.	..	..	–	..	..
	37	Do.	15– 8–14	19	+	..	R
	38	Do.	15– 8–14	19	+	..	R
	39	Do.	..	..	–	..	..
	40	Do.	..	..	–	..	..
	41–46	Controls	..	..	–	..	..
Trunk 8 ft. high 25th August 1910	..	Leaf-sheath	22–11–10	89	+	+	C
	..	This is a coconut palm No. 51 of Table IV.					

R = Row of spots on the expanding lamina.
C = Central leaf drying.
S = Spot on the leaf-sheath.
P = Spot on the petiole.
L = 3rd, 4th, 5th leaves drying.

TABLE V—*contd.*

	No. on palm	Part of the palm inoculated	Date of observing first symptoms	Interval of days	Infected	Dead	First symptom
Experiment IV	20	Leaf-sheath	9–9–14	25	+	+	C
	21	Do.	25–9–14	41	+	+	C
Palmyra to coconut palm	22	Do.	9–9–14	25	+	+	C
2½ years old	23	Do.	6–9–14	22	+	+	C
Date of inoculation, 15th	24	Do.	29–9–14	45	+	+	C
August 1914	25	Do.	17–9–14	33	+	+	C
	27	Do.	10–9–14	26	+	+	C
	30	Do.	..	..	−	..	..
	31	Do.	..	..	−	..	..
	32	Do.	..	..	−	..	..
	34	Do.	17–9–14	33	+	+	C
	35	Do.	13–9–14	29	+	+	C
	36	Do.	..	..	−	..	..
	37	Do.	..	..	−	..	..
	38	Do.	..	..	−	..	..
	47–52	Controls	..	..	−	..	..
Experiment V	1	Control	..	..	−	..	..
	2	Leaf-sheath	..	..	−	..	..
Coconut palm to coconut	3	Do.	3–1–14	29	+	+	C
palm	4	Do.	21–1–14	47	+	+	C
8 years old	5	Do.	4–4–14	120	+	..	S
Date of inoculation, 5th	6	Do.	..	..	−	..	..
December 1913	7	Central leaf	21–12–13	16	+	..	R
	8	Do.	21–12–13	16	+	..	R
	9	Do.	21–12–13	16	+	..	2R
	10	Control	..	..	−	..	..
Experiment VI	19	Central leaf	12–8–14	16	+	+	R
	20	Do.	15–8–14	19	+	+	R
Coconut palm to coconut	21	Do.	15–8–14	19	+	+	R
palm	22	Do.	..	..	−	..	..
1½ years old	23	Leaf-sheath	15–8–14	19	+	+	R
Date of inoculation, 27th	24	Do.	15–8–14	19	+	+	C
July 1914	26	Do.	17–9–14	52	+	+	C
	27	Central leaf	15–8–14	19	+	..	R
	28	Do.	17–9–14	52	+	+	R
	30	Petiole	15–8–14	19	+	..	P
	29	Controls	..	..	−	..	..
	43–45	Do.	..	..	−	..	..
Experiment VII	1	Central leaf	4–9–14	38	+	+	C
	2	Do.	..	..	−	..	..
Coconut palm to palmyra	3	Leaf-sheath	3–8–14	6	+	+	L
trunks 2–4 ft. high	4	Do.	10–8–14	13	+	+	C
Date of inoculation, 28th	5	Do.	5–8–14	8	+	..	C
July 1914	6	Central leaf	4–9–14	38	+	+	C
	7	Do.	4–8–14	7	+	+	C
	8	Do.	20–8–14	23	+	+	C
	9–12	Controls	..	..	−	..	..

R = Row of spots on the expanding lamina.
C = Central leaf drying.
S = Spot on the leaf-sheath.
P = Spot on the petiole.
L = 3rd, 4th 5th, leaves drying.

Experiment I. The culture was got from a palmyra in Gurusanapalli, Cocanada Taluq, on 20th November 1913 on quaker oat agar. For all except No. 10 the second subculture on quaker oat agar was used and for it the second subculture on French bean agar. The trunks of the palms were from two to eight feet high. In Nos. 1 to 6 where the leaf-base was inoculated the infective material was placed on the unwounded pale yellow surface of that part of the leaf-base which lay within the bud and which was exposed sufficiently by carefully but firmly pressing the leaf-bases apart. In Nos. 7, 8 and 10 the fungus was placed within the folds of an unexpanded leaf. Fifteen days after inoculation the central leaf was drying in Nos. 1 to 6 and the lower leaves gradually died in succession, and on 5th January 1914 they were dissected. The central leaf or leaves could be pulled out of the crown easily and their lower ends were rotting. Leaf-bases had the characteristic spots and some were also rotting. The tissue of the stem in the region of the growing-point instead of being of a pale cream colour was brown, soft and rotting. The fungus was present in the leaf spots and in the stem tissue and pure cultures were made from leaf-bases whose position was not nearer than the second within the inoculated leaf-base. In Nos. 7, 8 and 10 a fold of the unexpanded central leaf was inoculated. In Nos. 7 and 10 a row of spots was produced at the point of inoculation and the central leaves of No. 7 died. These two palms were dissected on 28th January 1914 and 5th January 1914 respectively and showed bud-rot. No. 8 did not become infected by 30th April 1914, nor did any of the nine controls.

Experiment II. The culture was got as in experement I but on French bean agar. The third subculture on French bean agar was used. The trunks varied up to four feet in height. In Nos. 9 to 12 the infective material was placed within the fold of the unexpanded central leaf and in Nos. 9 and 12 a small plug of wet cotton wool was inserted between the folds a little above the point of inoculation. A row of spots was formed on the expanding leaf in Nos. 10 and 12. As the leaf expanded the spots dried up and no other part of the palms became infected. Nos. 9 and 11 did not become infected. In Nos. 13 and 14 the infective material was placed between the central leaf which was just protruding from the bud and the expanding leaf, and in the latter a plug of wet cotton wool was placed. The central leaf in both palms produced a row of spots and the central group of leaves in both dried. On 29th August 1914 they were dissected and had bud-rot. In Nos. 15 and 16 the infective material was placed between the central leaf which was expanding and the next one and a plug of wet cotton wool was placed just above in the former. Forty-three days afterwards the central leaf of No. 16 dried

and other three leaves dried within three days. On dissection the palm showed bud-rot. No. 15 did not become infected, nor did the controls up to December 1914. In these two experiments *P. palmivora* Butl. produced in palmyras the characteristic spots on the leaf-base and on the lamina and after the fungus had reached the delicate tissue on the apex of the stem a bud-rot set in.

Experiment III. The culture was the same as for experiment II and the third subculture was also used. The palms were two-and-a-half years old. In Nos. 32, 33 and 39 the infective material was placed within the folds of an unexpanded leaf. In Nos. 31, 34, 37, 38 and 40 it was placed on the outside of the unexpanded leaf. In No. 35 it was washed down into the bud and in No. 36 it was placed between two petioles. In ten days the central leaf of No. 33 was drying and in nine days more three leaves outside it were dried. On dissection the palm showed bud-rot. In nineteen days No. 32 had a row of spots extending almost across the lamina. Nos. 31 and 34 had a row through three double segments of the folded lamina, No. 37 across half the breadth of the lamina and No. 38 across two-thirds, while No. 39 did not become infected. No. 35 had spots on the leaf-base of the expanding leaf and on two leaf-stalks while No. 36 did not become infected. The central leaf of Nos. 31, 32, 34, 37 and 38 had grown out into the air and was expanded. The spots dried up and produced no external mycelium though pieces placed in a moist chamber did. A coconut palm whose trunk was six feet high was inoculated on the Samalkota Farm on 25th August 1910 and dissected on 22nd November 1910. The inoculative material was aërial mycelium bearing sporangia from the leaf-sheath of a palmyra and was not an artificial culture. The central group of leaves was dead and was pulled out easily showing a soft rot at the torn ends; the leaf-bases had the characteristic spots; the leaf-bases, bud leaves, and the upper soft part of the stem were involved in a rot that had a nauseous smell, symptoms typical of the disease in the field. Other three palms in the group were unaffected and were still healthy years afterwards.

Experiment IV. The culture was the same as for experiment II, and the third subculture was used. The palms were two-and-a-half years old. The infective material was placed on the leaf-base of the second leaf in Nos. 21, 22, 34 and 35 of the third in Nos. 20, 23, 24 and 25, of the fourth in Nos. 27, 30, 32, 36 and 37, and of the sixth in No. 31, while in No. 38 it was placed on an injured place at the base of the crown. The central leaf of all but six of them dried at various dates indicated in Table V. The central leaf of No. 20 was dry after twenty-five days and five more leaves were dead eight days after: that

of No. 22 was dry after twenty-two days and three days after two more were dried. The others were similar. Once the central leaf had died the others below it died within a few days. They were all dissected and had bud-rot. Six did not become infected and the six controls remained healthy. In these two experiments *P. palmivora* Butl. from the palmyra produced in coconut palms the spots on the leaf-sheath and on the pinnæ, and after the fungus had reached the delicate tissue of the stem a bud-rot set in.

Experiment V. Cultures on French bean agar and on quaker oat agar were got from a coconut palm in Kurumathur in Malabar District on 14th November 1913. For Nos. 2 to 7 the first subculture on quaker oat agar was used and for Nos. 8 and 9 that on French bean agar. The palms were eight years old. The infective material was placed on the leaf-base in Nos. 2 to 6 and on the fold of the unexpanded leaf in Nos. 7 to 9 on 5th December 1913. On 3rd January 1914, twenty-nine days after inoculation, the central leaf of No. 3 was pale and came out when pulled lightly, on 31st January 1914 the next leaf was drying, on 26th February 1914 two more leaves were drying, but by 4th April 1914 no more leaves were dead and the palm was dissected. On 21st January 1914, forty-seven days after inoculation, the central leaf of No. 4 was pale, on 31st January 1914 the next two leaves were drying, on 14th February 1914 two more leaves were dried and the shoot had fallen over and was hanging down. On 26th February 1914 there was no further change and the palm was dissected. On 4th April 1914 there were no symptoms of disease on No. 5 so the palm was opened up. The leaf-base inoculated had a spot three inches in diameter extending to three-quarters of its thickness while the fibrous portion of the leaf-base next within had several small spots on a discoloured area four inches in diameter. Nos. 3 and 4 had spots on the leaf-bases and the bud was rotten. Nos. 7, 8 and 9 each had a row of spots extending over several segments sixteen days after inoculation and the last hab mycelium with sporangia on the surfaces of the spots. By 26th February 1914 two more rows of spots had developed on Nos. 7 and 9 and three on No. 8. On 4th April 1914 the diseased tissue was removed from Nos. 5, 7, 8 and 9. Nos. 2 and 6 were examined but had not become infected. The two controls were healthy and all but the two that were destroyed were healthy in July 1922.

Experiment VI. The culture was the same as for Experiment V on French bean agar and the third subculture was used. The palms were one-and-a-half years old. Nos. 19, 20, 22 and 27 were inoculated on the central unexpanded leaf, Nos. 21 and 28 on the under surface, No. 30 between the first and second petioles, No. 26 on the third leaf-base and Nos. 23 and 24

on the fourth. Nos. 19, 20, 21, 27 and 28 each produced a row of spots on the pinnæ of the central leaf, and two months after inoculation Nos. 19, 20, 21 and 28 were dead. No. 30 had a spot on each of the two petioles but the spot came through to the other side of each petiole as a discolouration only and no further symptoms appeared. In Nos. 24 and 26 the central leaf dried first, one early, the other later, and the other leaves in quick succession and both palms died. The first symptom on No. 23 was the presence of two rows of spots on the central expanding leaf, one extending from the midrib to the edge, and the other from the midrib almost to the edge but half an inch below the level of the other row. This was unexpected as the infective material had been placed between the fourth and fifth leaf. The palm was dead on 30th September 1914. No. 22 did not become infected and the five controls were healthy at the end of December 1914. The dead palms all had a soft rot which had gone so far that the leaf-bases were brown, soft and rotten, so that the spots were not distinctly differentiated. In these two experiments *P. palmivora* Butl. from a coconut palm produced in coconut palms spots on the leaf-sheaths and the pinnæ and after the fungus penetrated the bud a bud-rot set in.

Experiment VII. The culture was the same as in Experiment V on French bean agar and the third subculture was used. The palms had trunks from two to four feet high. The infective material, a minute piece of agar with mycelium and sporangia, was placed in Nos. 1, 2, 6, 7 and 8 between the protruding leaf and the expanding leaf, in Nos. 3 and 4 between the third and fourth leaf and in No. 5 between the sixth and the seventh leaf. No. 2 did not take the infection within the five months of observation. The others showed the drying of the central leaf as the first symptom except No. 3 where the first symptom was the drying of the third, fourth and fifth leaves almost simultaneously. No. 4 had three leaves dried and No. 3 twelve on 13th August 1914, sixteen days after inoculation, while No. 1 had six and No. 6 eight on 17th September 1914, fifty-one days after inoculation. The central leaf was pulled out easily, spots were found one after the other in line, and the bud had a soft stinking rot. In No. 5 sixteen days after inoculation the three uppermost expanded leaves were drying, the central leaf had a spot on its petiole, five leaf-bases had spots and the soft part of the tissue of the stem had a soft rot but it had not actually involved the growing-point though it had come within half an inch of it. In No. 7 on 27th August 1914 two leaves were dried up, spots were present in line on the folded leaf, the petiole of the expanding leaf and on the leaf-bases of the next two leaves. There was also a spot on the folded leaf two inches below the point of inoculation

and the region of the growing-point was rotting. In No. 8 on 20th August 1914 the central leaf was drying, seven days later the protruding leaf came away on pulling lightly and its base was discoloured and rotten. It was dissected and the region of the growing-point was rotting as well as the leaf-bases of the next three leaves. The four controls remained healthy till the end of December 1914. This experiment shows that *P. palmivora* from a coconut palm will infect the palmyra and that after it has invaded the soft tissue on the apex of the stem a bud-rot ensues.

In these experiments care was taken to incubate sufficient material from each experiment to make sure the fungus was present and to get it into culture again for comparison. Sections were also taken in all cases to demonstrate the presence of the fungus within the respective tissues.

Butler proved that *Phytophthora palmivora* would infect the living leaves of the palmyra, while Shaw and Sundararaman proved that it would infect living leaves of the coconut palm and kill seedlings. These experiments confirm and amplify those of Butler, Shaw and Sundararaman, definitely show that *P. palmivora* will lead to the death of both the palmyra and the coconut palm, that it can pass from one to the other palm and that all the symptoms of bud-rot have been re-produced in both palms as a result of infection by this fungus. When the fungus penetrates the soft tissue of the stem below the growing-point the tissue is killed and a rot ensues. Other organisms then begin to work and carry on the rot at a greater rate than the fungus does till the whole central part of the crown is involved. That the fungus is the primary cause of the rot and the controlling factor in the epidemic form in South India is all that is claimed. From the economic point of view these other organisms are of secondary importance and have not been worked out. These results meet completely the criticism of Sharples and Lambourne[1] regarding the cause of bud-rot of palms in India.

[1] Sharples and Lambourne. Observation in Malay on Bud-rot of Coconuts. *Ann. Bot.*, Vol, XXXVI, pp. 64—69, 1922.